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Osteology of the Central Mudminnow, *Umbra limi*

CLARENCE F. DINEEN AND PAUL S. STOKELY

THE vagaries of the relationships of the central mudminnow, *Umbra limi* (Kirtland), together with the spotty distribution of its relatives in the family Umbridae, prompted us to carry out as complete a study of the species as was practicable. A statistical analysis of the growth of the mudminnow revealed that some allometry did occur, although of small magnitude (Stokely and Dineen, 1953). Work is in progress on the ecological aspects of the life history of this fish. This study of its osteology is an attempt to supplement the work of Starks (1905) on *Dallia pectoralis* and Chapman (1934) on *Umbra limi*, *Novumbra hubbsi* and *Dallia pectoralis*.

This report is based upon 26 cleared and stained specimens (Davis and Gore, 1936) ranging in standard lengths from 30 to 115 mm. that were collected during the summer and fall of 1952 from Judy Creek, just north of the campus of the University of Notre Dame. All but the four smallest individuals were sexed, there being 13 females and 9 males. There was a preponderance of females among the larger specimens, as was found by Applegate (1943).

The authors wish to extend their thanks to Mr. Robert J. Shaver, research assistant in the Department of Biology, University of Notre Dame, for his drawings. The figures are free-hand sketches made while making observations with a low-power, binocular microscope.

**VERTEBRAL COLUMN.**—The vertebrae, including the urostyle, vary as follows: 35 (1 specimen), 36 (15) and 37 (10). (Chapman, 1934, stated that *Umbra* has 35 vertebrae.) There is no apparent correlation between sex and vertebral count. In the specimen with only 35 vertebrae, the vertebra immediately in front of the antepenultimate has two epurals above, although only the anterior one is functional, and two functional hypurals below. This indicates the fusion of two vertebrae and may point to one method by which vertebrae are lost.

Taking the first completely developed haemal arch (Fig. 1) to indicate the first caudal vertebra (even though the two elongated sides of the arch may have failed to fuse to form a spine), the precaudal or trunk vertebrae vary from 20 (22) to 21 (4). In three of the latter, the total number of vertebrae is 37, suggesting that the extra vertebra is in the trunk region. But in the fourth individual, with the total of 36 vertebrae unchanged, the development of the first complete haemal arch on the twenty-second rather than on the twenty-first vertebra, as is usual, may account for the additional trunk vertebra. In those specimens with 20 trunk vertebrae it appears that seven with an extra caudal vertebra account for the total count of 37.

With slight variation, the centra throughout the vertebral column are the same size. The centrum of the antepenultimate vertebra and the two immediately anterior to it are slightly shorter (Fig. 2). This is true also of the foremost vertebra in the column. The posterior half of each amphicoelous centrum is a little larger than the anterior.

Dorso-laterally on each centrum, thin sheets of bone, at right angles to the long axis of the centrum, extend caudad from the bases of the neural arch. They form wing-like projections on the posterior end of all the centra except the four just anterior to the urostyle (Fig. 2). These projections may extend slightly beyond the posterior end of the centrum but they never contact the base of the next neural spine. On the ventro-lateral area of the centrum, thin sheets of bone, tangential to the long axis of the centrum, form wedges between its convex ends. On the caudal vertebrae these wings extend from the bases of the haemal arches (Fig. 1). Such ossifications add rigidity to the centra which, because of the sharp constriction in the middle, might otherwise be rather weak. In some centrarchid fishes, similar results are obtained by a somewhat different arrangement (Stokely, 1952).

No fenestrae were noted in any of the

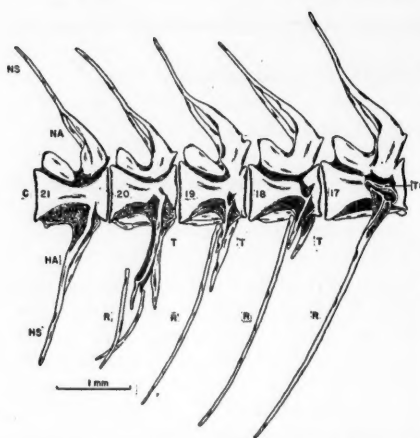


Fig. 1. The 17th through the 21st (first caudal) vertebrae.

C, centrum; HA, haemal arch; HS, haemal spine; NA, neural arch; NS, neural spine; R, rib; T, transverse process.

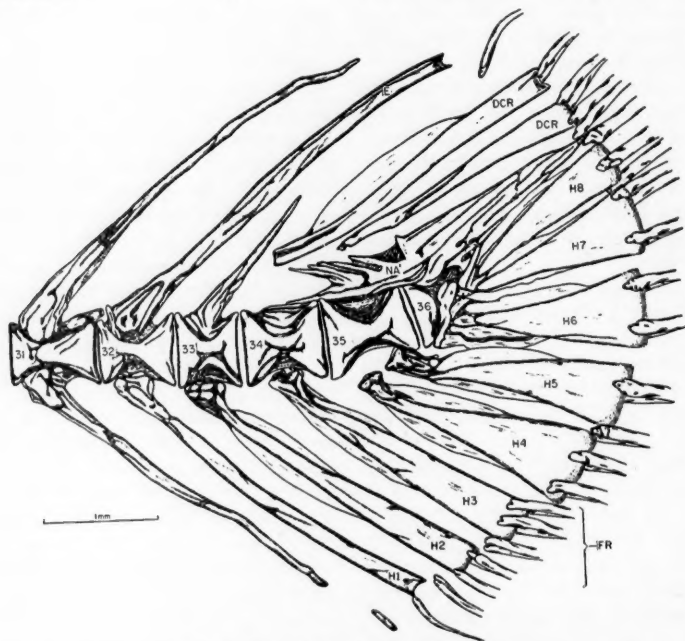


Fig. 2. Caudal fin with the last six vertebrae.

DCR, dorsal caudal radial; E, epural; FR, fin rays; H, hypural; NA', extra neural arch.

vertebrae. The ventral surfaces of the centra are variously pitted, but this pitting shows no regularity as was observed by Starks (1905) in *Dallia*.

The first vertebra, a little smaller than the rest, has no modification for articulation with the skull (Fig. 6). It bears no ribs but the transverse processes are pointed, stout and half-again as long as those on the next vertebra. These furnish areas for muscle attachment of the spinal column to the skull and a ligament to the supracleithrum.

The neural arches and spines are complete on all vertebrae except the most posterior three or four and the urostyle. There is no modification of the neural spines for the support of the radials of the dorsal fin, although the neural spines underneath the dorsal fin are shorter.

Lying free in front of and paralleling each neural spine, from the first one to as far caudad as the anterior end of the dorsal fin, are from 14 to 16 slightly curved bones with their long axes oriented dorso-ventrad. These bones were termed "interneurals" by Chapman (1934). The dorsal portion of the first two is slightly

broader than the rest. Proceeding posteriorly there is a gradual increase in the length of these interneurals.

Epineurals are found associated with each

vertebra except the most posterior three or four. They are ankylosed to the base of the neural arch in the anterior region of the column but lie free in the myosepta along the caudals and the most posterior two or three trunk vertebrae. No epipleurals are present.

The condition of the transverse processes on the first vertebra has been described above. On most of the other trunk vertebrae they are short, blunt projections from the centra that provide on their distal end, a cup-shaped receptacle for the head of a rib (Fig. 1, 17). The transverse processes are located laterally on the centra but become more and more ventral in position in the posterior part of the trunk region (Fig. 1). On the last three or four trunk vertebrae, the transverse processes become progressively longer proceeding caudad and instead of a rib articulating at the end of the transverse process, it is attached to the posterior side of the tip. The elongated transverse processes eventually fuse to form the haemal arch, which becomes prolonged into a haemal spine.

Epihaemals are present throughout the caudal region, similar to the epineurals. These bones ossify from the distal end proximad and are rarely ossified at the point of attachment to the haemal arch.

Excepting the first, ribs are found associated with all of the vertebrae in the trunk region. The ribs are quite uniform but a little shorter on the second and third vertebrae and, as mentioned above, there is a shortening of the rib and a lengthening of the transverse processes on the last three or four vertebrae in the trunk region. Where the rib articulates with the end of a transverse process, the proximal end is widened and fits snugly into the concavity of the transverse process.

Five vertebrae including the urostyle are involved in the support of the caudal fin (Fig. 2). On the foremost vertebra in this group, the neural spine, to different degrees, is elongated, widened distad and supports a caudal fin ray (Fig. 2, 32 E), thus functioning as a true epural. The neural spine of the vertebra just posterior is reduced and gives no support to the caudal fin (Fig. 2). In about half of the specimens, however, the neural spine is unmodified on the foremost of these five vertebrae and in these individuals the neural spine on the next posterior vertebra is not reduced but

functions as a typical epural. The hypural on the foremost vertebra in the caudal fin series (Fig. 2, 32) is plainly an elongate and broadened haemal spine supporting two or three fin rays. There is still a good haemal arch, which may or may not be fused to the centrum.

On the next posterior vertebra (Fig. 2, 33) the neural spine, as stated previously, is either a functional epural or reduced to a spur. In all there is an autogenous hypural, with a haemal arch and an elongate, broadened haemal spine which supports two or three caudal fin rays.

On the dorsal portion of the centrum of the antepenultimate vertebra, there is either a vestige of a neural arch or nothing (Fig. 2, 34). Above, a dorsal caudal radial supports two or three caudal fin rays. Ventrally, an autogenous hypural has two fin rays attached to its distal end while its proximal end functions as the last haemal arch in the vertebral column.

On the penultimate vertebra there is no sign of a neural arch. A dorsal caudal radial above has two fin rays attached (Fig. 2). Below the centrum there are two autogenous hypurals and neither shows any trace of a haemal arch. The anterior hypural (H4) is considerably wider than the posterior one (H5); together they support four or five rays. In 2 of the 26 specimens this is the last vertebra in the column and, though reduced, shows no typical urostylar elongation.

The last or ultimate vertebral segment, the urostyle, (Fig. 2, 36) is made up of the anterior cup of a typical hour-glass centrum and is continued caudad as a short, upturned vestige. There is no elongate urostylar process. Whitehouse (1910) stated that an elongate urostylar process indicated a low degree of specialization.

Three hypurals are associated with the urostyle, the most posterior (H8) being but half as wide as the others. Each supports two fin rays. The last five hypurals are held together at their extremities by uncalcified cartilage.

Above the penultimate and ultimate vertebrae lies an autogenous bony mass of irregular shape which probably represents a fusion of several reduced neural arches. At least the more posterior portion of the mass can be seen to be made up of right and left moieties. It is possible that the thickened posterior edges of this bone might be formed by the secondary

fusion of dorsal caudal radials with neural arches.

**DORSAL FIN.**—The total number of dorsal rays (regardless of size or structure) varies from 14 to 17; all except two have 15 or 16. The number of branched rays varies from 11 to 13. The last dorsal ray is branched in every specimen examined. As is found in Ameiuridae, Esocidae and Salmonidae (Hubbs and Lagler, 1949), the anterior three or four rays are unbranched and grade into the branched rays

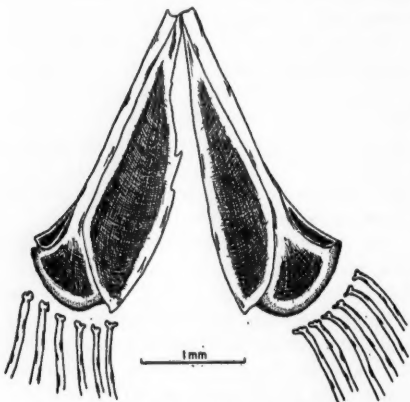


Fig. 3. Pelvic girdle and fins (ventral view).

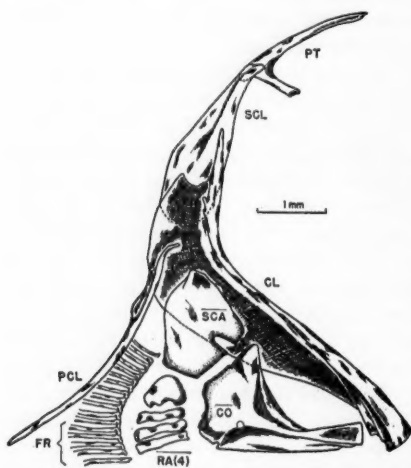


Fig. 4. Right half of the pectoral girdle and right pectoral fin (mesial view).

CL, cleithrum; CO, coracoid; FR, fin rays; PCL, postcleithrum; PT, posttemporal; RA, radial; SCA, scapula; SCL, supracleithrum.

in length. It was noted that the degree of branching increases with the size of the fish.

The number of pterygiophores in the dorsal fin varies from 14 to 17. The dorsal end of a pterygiophore fits under the base of a dorsal ray. Near the dorsal posterior end of each pterygiophore is a small ossification. These ossifications are better developed near the pterygiophores under the central portion of the fin and may even be fused with the pterygiophores in this region to form heel-like spurs. Toward either end of the fin such ossifications become smaller and are missing from the first four and last six or seven pterygiophores, and absent altogether in a few specimens. These little elements show a greater degree of ossification with size. Between the bases of the two halves of a fin ray, there appear tiny blocks of calcified cartilage.

**ANAL FIN.**—The anal fin begins just ventral to the tip of the third most posterior rib. Chapman (1934) gave eight as the number of anal fin rays; evidently he counted only the principal rays (the branched plus one unbranched ray). However, the total number of anal fin rays, regardless of size or structure, varies from 10 to 13; 17 of the 26 specimens have 11. The number of branched rays varies from six to eight. The anterior two to four rays are unbranched and grade into the branched rays in length. The last ray is small and unbranched. The number of pterygiophores varies from 8 to 10 with 15 of the 26 specimens having 9.

**PELVIC GIRDLE AND FINS.**—The pelvic girdle consists of paired basal elements each associated with six fin rays without exception. Each basal element seems to be a fusion of two parts. Its anterior border lies under the tip of the twelfth from the last rib. The basal element from each side approximates its partner at the mid-ventral surface of the fish. The elements are held together by a ligament and contact each other only at their tips (Fig. 3).

**PECTORAL GIRDLE AND FINS.**—The pectoral girdle consists of paired elements arranged six on a side, running from a point of ligamentous contact with the skull on the dorsal surface to the midventral surface where the cleithra are connected by a ligament (Fig. 4).

The posttemporal, supracleithrum and cleithrum form a chain of essentially long narrow bones (Fig. 4). The narrow anterior

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end of the spatula-shaped supracleithrum is overlapped by the forked posttemporal. The widened posterior end of the supracleithrum overlaps the notched anterior end of the cleithrum. The posttemporal is held firmly to the epiotic by ligamentous attachment. The cleithrum, longer than the combined lengths of the other two, is broadened on the dorsal end and extends ventrad, narrows, curves anteriad and is joined by a ligament at the midline to its partner from the other side. The postcleithrum is a spindle-shaped bone placed at an angle with its longitudinal axis directed posteroventrally. Its anterior end lies under the cleithrum while the posterior end is imbedded in muscle underneath the pectoral fin.

The coracoid is a roughly triangular bone with the base of the triangle at its posterior end. The apex of the triangle attaches to the cleithrum by a tough ligament. The mesial edge of the coracoid is quite straight and has the characteristic foramen. The scapula is a subquadrate bone with a deep notch on its ventral border. The anterior half lies underneath the cleithrum and is fused to it.

Four radial bones support the pectoral fin rays. The most dorsal one is considerably thickened and often partially fused to the next one. The most ventral two are usually fused to some extent and in two specimens completely so. The radials as well as the coracoid and scapula apparently arise as separate centers of ossification in a single cartilage matrix. The number of pectoral rays varies from 15 to 16.

**CRANIUM.**—There is a gradual increase in the extent of ossification with age (as determined by the relative size) in the mudminnow. Some of the investment bones overlap in the larger skulls, e. g., the frontals along the midline; but these bones are well separated in the small skulls. Calcification is one of the normal regressive changes of cartilage and usually precedes replacement of cartilage by bone (Maximow and Bloom, 1944: 121). Since the method of clearing and staining used in this study differentiates cartilage, calcified cartilage and bone, the gradual replacement of cartilage by bone with age was clearly shown in the primary bones, particularly in the otic and occipital series. There is slightly greater fusion of bones in the larger skulls. Individual

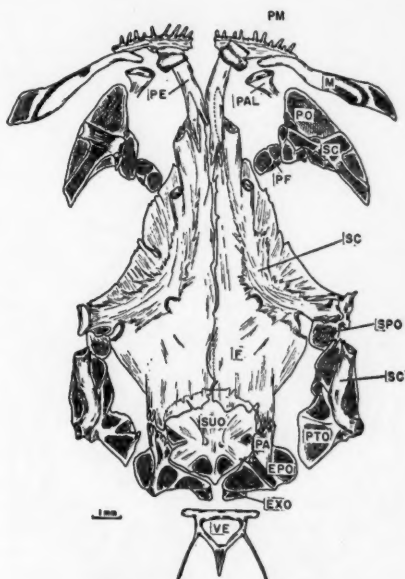


Fig. 5. Skull of 94-mm. central mudminnow (dorsal view).

EPO, epiotic; EXO, exoccipital; F, frontal; M, maxillary; PA, parietal; PAL, palatine; PE, proethmoid; PF, prefrontal; PM, premaxillary; PO, preorbital; PTO, pterotic; SC, sensory canal; SPO, sphenotic; SUO, supraoccipital; VE, vertebra.

differences were noted in a slight variation in the number of branchiostegal rays, in the number of teeth on the vomer and in the length of the crest and spine on the posterior end of the supraoccipital.

Large frontals cover most of the dorsal surface of the cranium (Fig. 5). Lateral projections are fused to the anterior halves of the sphenotics. Posterior extensions of the frontals are divided into uneven projections that interdigitate with similar projections on the anterior edges of the parietals. These extensions form a large U-shaped notch in which the supraoccipital is located. The frontals cover about one-sixth of the supraoccipital. The anterior extension of each frontal terminates in a narrow outer projection which lies under the posterior one-half of its respective proethmoid (more than one-half in the larger skulls). As stated by Chapman (1934), very short mesial, anterior projections of the frontals lie over the posterior ends of the proethmoids. This is true only in the larger specimens.

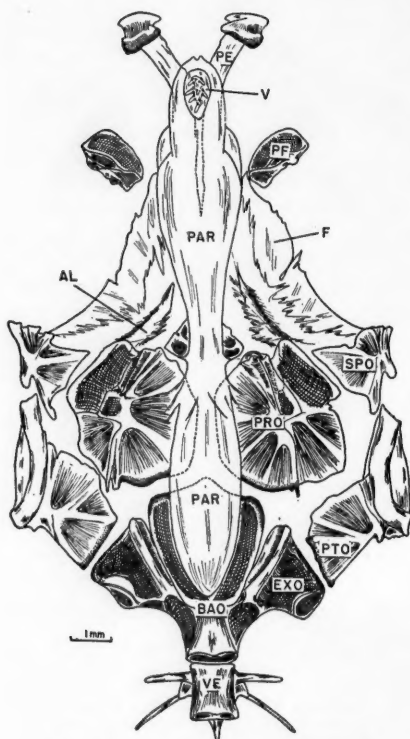


Fig. 6. Cranium of 94-mm. central mudminnow (ventral view).

AL, alisphenoid; BAO, basioccipital; EXO, exoccipital; F, frontal; PAR, parasphenoid; PE, prothmoid; PF, prefrontal; PRO, prootic; PTO, pterotic; SPO, sphenotic; V, vomer; VE, vertebra.

A sensory canal extends along the lateral border of each frontal from its point of attachment to the sphenotic to a point slightly anterior to the prefrontal. In addition to the openings at the ends of each canal, a pore opens to the dorsal surface at the bend in the canal and another about half way from this point to the anterior terminus (Fig. 5).

Alisphenoids form descending wings from the frontals in the postero-dorsal region of the orbits. They articulate posteriorly with the sphenotics and prootics. The alisphenoids can be detached from the frontals without great difficulty. They do not meet along the midline (Figs. 6 and 7).

As stated by Chapman (1934) the elongate proethmoids are about eight times as long as their greatest width. The anterior ends of the

proethmoids form V-shaped nodules (largely calcified cartilage) which are easily detached from the smaller specimens but firmly fused in the larger ones. These nodules form caps on the anterior edge of the rostral cartilage and lie in depressions on the dorso-mesial surfaces of the premaxillaries.

The prefrontals are flattened, wide-based cones capping the postero-lateral edges of the rostral cartilage.

The flat triangular preorbitals are attached lightly to the antero-lateral surfaces of the cranium. Each bears a triangular sensory canal with three pores (Fig. 5).

The parasphenoid is a single, elongate, flat bone extending along almost the entire midline of the ventral surface of the cranium (Fig. 6). As in *Novumbra* (Chapman, 1934), its broadly rounded anterior end is in contact with the ventral surface of the rostral cartilage. Lightly ossified wings extending latero-ventrad are united to the thin mesopterygoids by broad membranes, forming collectively a large portion of the roof of the mouth. The lateral projections extending in the direction of similar projections on the prootics (Fig. 6) are considerably smaller than those of *Novumbra* (Chapman, 1934, Fig. 5). The posterior end of the parasphenoid covers (ventral view) the mesial portions of the prootics and the basioccipital. The pointed terminus is midway from the anterior edge of the basioccipital to the occipital condyle.

A small sub-oval vomer is attached loosely to the under surface of the anterior end of the parasphenoid. The number of teeth on the vomer varies from two to seven.

The parietals are flat triangular bones with the apex of each directed posterior and firmly fused to the respective epiotic (Fig. 5). The mesial margins overlie a small part of the supraoccipital which widely separates the two parietals as in *Dallia* but not in *Novumbra*, where the parietals meet at the midline (Chapman, 1934, Fig. 4). Anteriorly the parietals articulate with the frontals.

The supraoccipital and exoccipitals as well as the sphenotics, pterotics and epiotics do not represent complete ossifications but each has an inner and outer layer of bone separated by an unossified region. In the supraoccipital there is solid bone in the center but separate inner and outer layers of bone toward the periphery.

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The single, median supraoccipital is in contact with the epiotics, parietals and frontals. (See previous notations.) In many specimens a prominent crest on the posterior end of the supraoccipital extends ventro-caudad as a spine beyond the edge of the bone proper. The crest and spine are ossifications in a tendon and their extent varies considerably but is not closely correlated with the age of the mudminnow.

The exoccipitals articulate with the basioccipital, the pterotics and epiotics, thus forming a major part of the posterior surface of the cranium. In the latter two areas of articulation the bones are separated by cartilage. The V-shaped wings of the exoccipitals which extend dorsad over the foramen magnum do not meet on the dorsal surface (Fig. 5). The posterior projections do not contact the first vertebra.

The posterior end of a single, median basioccipital forms the entire occipital condyle. Anteriorly it is a flattened bone with a concave ventral surface in which the posterior end of the parasphenoid lies. A prominent bridge of cartilage unites the basioccipital to the posterior edges of the prootics. Part of each concavity in which an otolith lies is formed by the basioccipital.

There are four pairs of otic bones in the skull of *Umbra limi*; namely, prootic, sphenotic, pterotic and epiotic (Figs. 5, 6 and 7).

The flat, butterfly-shaped prootics are widely separated along the midline by a band of cartilage and, in the smaller specimens, are surrounded by a band of calcified cartilage. As previously stated, calcified cartilage is an intermediate stage in the process of primary bone formation. The extent of ossification increases with age (size of the skull). Similarly the pterotics are separated by cartilage from the basioccipital, exoccipitals, pterotics and sphenotics. The anterior edges are curved to form, along with the alisphenoids, the posterior border of the orbits. A foramen in the center and a large notch in the anterior edge of each prootic form openings for nerves (Fig. 6). The relation of the prootics to the parasphenoid has already been discussed.

The sphenotics are hollow cones forming the postero-lateral corners of the orbits. The apex of each cone is directed antero-laterad and the lateral projections of the frontals are firmly

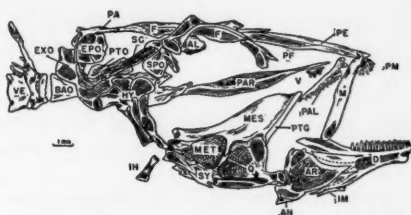


Fig. 7. Skull of 94-mm. central mudminnow (lateral view, preorbital and opercular bones removed).

AL, alisphenoid; AN, angular; AR, articular; BAO, basioccipital; D, dentary; EPO, epiotic; EXO, exoccipital; F, frontal; HY, hyomandibular; IH, interhyal; IM, inframandibular; M, maxillary; MES, mesoterygoid; MET, metapterygoid; PA, parietal; PAL, palatine; PAR, parasphenoid; PE, proethmoid; PF, prefrontal; PM, premaxillary; PTG, pterygoid; PTO, pterotic; Q, quadrate; SC, sensory canal; SPO, sphenotic; SY, symplectic; V, vomer; VE, vertebra.

fused to the antero-dorsal surfaces. The anterior end of a short sensory canal along with its dorso-mesial wing is fused to the postero-dorsal surface of each sphenotic (Fig. 5).

The pterotics are wide-based, collapsed cones with the apex of each directed postero-laterad. They articulate with the prootics and exoccipitals on the ventral surface of the cranium and with the epiotics on the dorso-posterior edge. The anterior ventral surface of each pterotic serves as an articulating surface for the dorsal head of the respective hyomandibular. The posterior end of each sensory canal and wing mentioned in the preceding paragraph, is fused to the lateral surface of the respective pterotic.

The apex of each cone-shaped epiotic forms an attachment point for a ligament connecting it to the respective posttemporal. The epiotics articulate with the supraoccipital, exoccipitals and pterotics. The parietals are fused to the antero-dorsal surfaces.

Starks (1926) stated that in the majority of fishes the pterygoid joins the quadrate and the palatine, and that *Umbra* and *Dallia* were exceptions in that the pterygoid was missing in these two genera; instead the palatine was connected directly to the quadrate. The same condition was reported by Chapman (1934) for *Novumbra*, *Dallia*, and *Umbra*. However, the present investigation revealed a typical pterygoid bone in *Umbra limi* (Fig. 7).

The palatines are elongate bones extending from the anterior end of the rostral cartilage

to the pterygoids which they overlap and join by cartilage. Each palatine bears a double row of teeth.

The pterygoid on each side is a splint-like bone joined by cartilage along the entire anterior margin of the mesopterygoid and part of the quadrate.

Each mesopterygoid is an elongate, thin sheet of bone joined to the pterygoid, quadrate and metapterygoid. The mesopterygoid is fused to the mesial side of the latter two bones. From this region of fusion, the mesopterygoid extends dorso-mesial over a portion of the roof of the mouth (Fig. 7).

Each metapterygoid is a thin bone fused to the symplectic, quadrate, mesopterygoid and ventral process of the hyomandibular (Fig. 7).

**OPERCULAR SERIES.**—The operculars are triangular bones with slightly convex margins. The dorso-anterior angle of each is modified for articulation with the process of the hyomandibular.

The side of each triangular subopercular bone, adjacent to the opercular, is concave. The posterior angle of the subopercular extends a short distance beyond the anterior margin of the opercular. This projection is much shorter in our specimens than in the illustration by Chapman (1934, Fig. 3).

The ventral margin of each interopercular is rounded and the posterior surface covers a small portion of the subopercular. The dorsal half is covered by the preopercular.

Each preopercular is a sharply curved bone, almost forming a right angle. The dorsal portion is braced on its postero-mesial surface by the wing-process on the hyomandibular. There is a groove on the dorsal surface of the anterior portion of the preopercular which receives the stout spur from the quadrate and thus lends considerable support to the jaw. In some fishes, such as the channel catfish (Eaton, 1948), the preopercular forms the principle jaw support. A sensory canal traverses the entire outer surface of the preopercular. In addition to the two terminal pores, there are two apertures opening posteriorly near the angle of the bone (five openings in *Novumbra* and *Dallia*; Chapman, 1934).

**UPPER JAW.**—The premaxillaries are small elongate bones bearing teeth on the entire under surface (Figs. 5, 7). The dorsal surfaces are

modified to receive the anterior ends of the proethmoids and maxillaries.

Each maxillary is a spatula-shaped bone with the posterior end about twice as wide as the anterior. The anterior tip rests in a dorso-lateral depression of the premaxillary and is curved slightly in the direction of a small notch in the lateral edge of the anterior nodule of the proethmoid (Fig. 7).

The base of each fan-shaped quadrate bone forms a concave condyle which articulates at right angles to a similar condyle on the articular. A stout process from the posterior edge lies in a groove along the antero-dorsal edge of the preopercular and is firmly attached to the symplectic. The quadrate thus becomes the keystone in the support of the jaw by way of the hyomandibular and associated bones on the one hand and the palatine-ptyerygoid series on the other (Fig. 7).

**LOWER JAW.**—The V-shaped posterior extension of each dentary is fused to the lateral side of the anterior portion of the respective articular (Fig. 7). The dentaries are enlarged slightly at the point of contact with one another along the midline. The dorsal surface of the posterior one-fourth of each is toothless.

The anterior corner of each triangular articular is fused to the respective dentary as stated above. The condylar corner is thickened and forms a U-shaped articulating surface.

Each angular is a thickened triangular bone firmly fused to the inner surface of the articular ventral to the condylar surface.

The inframandibulars are short, splint-like bones fused solidly to the mesial sides of the lower posterior edges of the dentaries. It was impossible to detect these bones in some specimens; sometimes they were present only on one side. This absence is either the result of complete fusion with the dentary or of failure to develop.

Small sesamoid articulars (Starks, 1916) are fused to the mesial surfaces of the articulars, slightly forward of the center.

**JAW SUSPENSION-HYOM. ARCH.**—The posterior half of the large cranial surface of each hyomandibular articulates with the pterotic; the anterior half articulates with the cartilaginous area between the prootic and sphenotic. A strong posterior arm joins the opercular. A lateral wing, at right angles to the main axis of the hyomandibular, extends

from a point a little below the center of the upper portion of the bone, ventrad along the main process of the hyomandibular (Fig. 7). This wing is in contact with the preopercular. A small foramen is found adjacent to the wing. The blunt terminus of the main ventral process is joined to the upper end of the symplectic by a band of cartilage which is at least as long as the width of the main ventral process. A thin, splint-like process of the hyomandibular extends to the metapterygoid to which it is fused at the point of contact.

Each symplectic is an irregular, rod-shaped bone with its main axis curved; one arm is directed postero-dorsad, joining the hyomandibular by a cartilaginous band, and the other arm is directed antiad (slightly ventrad). A lightly ossified wing of the symplectic extends under, and is fused to, the metapterygoid and quadrate. The strong posterior process of the quadrate parallels the anterior arm of the symplectic.

The two lateral cornua of the hyoid arch are made up of several bones laid end to end and the two sides are joined ventrally by a single unpaired keystone bone. All arch components have a rim of calcified cartilage at each end and all are separated from each other by an interval of uncalcified cartilage.

Each interhyal is a tiny rod of bone linking the epihyal to the cartilaginous block between the hyomandibular and the symplectic (Figs. 7 and 8).

The epihyal of each cornua is an irregular quadrilateral bone between the interhyal and ceratohyal. The largest (last) branchiostegal is attached by cartilage to the lateral, anterior surface of each epihyal or to the cartilaginous area between the epihyal and the ceratohyal.

The hour-glass ceratohyals (Fig. 8) have lateral, toothed projections extending antiad over part of the hypohyals. Usually three branchiostegals are attached to each ceratohyal. The posterior two are attached by cartilage to the lateral surface of the postero-ventral corner, and the tip of the anterior one to the ventral surface of the ceratohyal at the point of its least diameter.

The hypohyal is double on each side. Each part is cone-shaped with the ventral cone about twice the size of the dorsal cone. The bases of the cones are in contact with one another.

The basihyal (glossohyal of Chapman, 1934)

is an unpaired tubular rod with a core of uncalcified cartilage. The anterior end, largely calcified cartilage, is twice as wide as the posterior.

The unpaired, medial basibranchiostegal (terminology of Parker and Haswell, 1949; urohyal of Chapman, 1934) is embedded in the muscles of the isthmus and is attached by ligaments to the apexes of the ventral cones of the hypohyals. It is made up of two flat plates: a large, vertical vane at right angles to a small, ventral, horizontal plate.

The foremost branchiostegal is the smallest and each succeeding one is typically twice as broad as the one immediately in front of it. There are four branchiostegals on a side (Chapman, 1934, gives six or seven for *Umbra*) but in one specimen examined for this report, there was an extra branchiostegal on one side and in another specimen, an extra one on both sides.

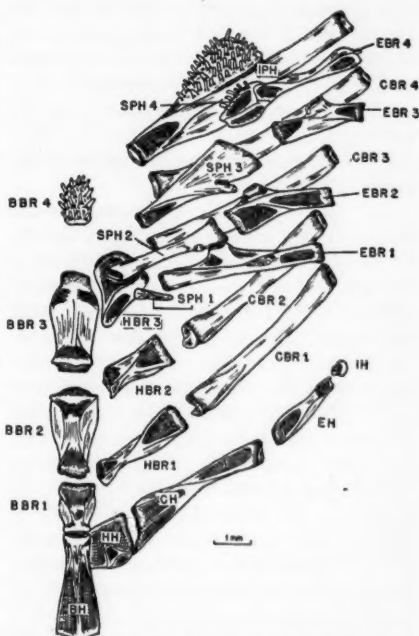


Fig. 8. Basal elements and left halves of the hyoid and branchial arches (dorsal view). BBR, basibranchial; BH, basihyal; CBR, ceratobranchial; CH, ceratohyal; EBR, epibranchial; EH, epihyal; HBR, hypobranchial; HH, hypohyal; IH, interhyal; IPH, infrapharyngeal; SPH, suprapharyngeal.

**BRANCHIAL ARCHES.**—The components of the branchial arches have the same general arrangement as those of the hyoid arch. Likewise similar are the calcified and uncalcified cartilaginous areas connecting the ossified elements of the branchial arches.

Four unpaired basibranchials lie in the mid-ventral line of the pharynx (Fig. 8). The anterior three are tubular rods with cartilaginous cores. The first element is smaller than the succeeding two. The fourth basibranchial (BBR 4) is considerably smaller than the others and bears teeth on its entire dorsal surface.

The hypobranchials, in contrast to the double hypohyals, are single, elongate bones in each half of an arch. The first hypobranchial fits into a notch in the cartilage between the first and second basibranchial. Similarly, the second (slightly shorter than the first) is attached between the second and third basibranchials. The third hypobranchial is a circular mass with a process extending antero-ventrad. The circular portion is lateral to the posterior end of the third basibranchial. As stated by Starks (1905), there is no fourth hypobranchial.

The four slender, rod-shaped ceratobranchials are very similar and, together with the three hypobranchials, form the lower halves of the arches (Fig. 8).

The first of the four epibranchials is the longest and has a small process which extends to meet (by way of a cartilaginous interval) a similar structure on the second suprapharyngeal (EBR 1 and SPH 2). Likewise the second epibranchial, though shorter than the first, has a process extending to meet a similar structure on the third suprapharyngeal. The third epibranchial is considerably smaller than the second but has a similar process; however, the fourth suprapharyngeal bears no process and is not in a position to articulate with the process on the third epibranchial (EBR 3, SPH 4). The ventro-mesial end of the fourth epibranchial is joined by cartilage to the dorsal surface of the fourth suprapharyngeal. A large vane-like structure on the fourth epibranchial is in the same position as the process of the preceding three epibranchials. (This is not distinguishable in dorsal view as in Fig. 8.)

The first suprapharyngeal is only one-fourth the size of the rod-shaped second suprapharyngeal. The third is slightly thicker than the

second and bears a large plate of teeth on its ventral surface. The process on the second and third, and their relation to similar processes on the epibranchials, are discussed in the preceding paragraph. The fourth suprapharyngeal is a disc of bone bearing teeth on its ventral surface.

The fifth branchial arch is represented on each side by a single element (infrapharyngeal, Chapman, 1934) with a large mass of teeth fused firmly to the postero-mesial surface. The toothed portion of the infrapharyngeals are widely separated from one another and from the toothed fourth basibranchials by a cartilage mass (Fig. 8). This is in considerable contrast to *Novumbra* (Chapman, 1934) where the toothed areas of the infrapharyngeals meet at the midline.

There is a row of ossified gillraker supports, of various sizes, on the anterior and on the posterior edges of the first four branchial arches. Each row has 9 to 10 on the lower halves and 4 to 5 on the upper halves. A row of 7 to 8 gillraker supports is found on the anterior edge of each of the fifth branchial arch elements.

**DISCUSSION.**—The item of greatest significance brought out by this study of the osteology of the central mudminnow, *Umbra limi*, is the presence of a typical pterygoid in this fish. Both Chapman (1934) and Starks (1926) stated that *Umbra* lacks this bone. Likewise the vertebral count of 36 to 37 disagrees with Chapman's figure of 35 for *Umbra*. While Chapman recorded six to seven branchiostegals, in the present study four was found to be the normal number, with rarely five on one or both sides. An inframandibular is not a constant feature but is sometimes completely lacking or detectable only on one side. Taking relative size as an indication of age, the extent of ossification increases with age. Projections from bones that are prominent in adult specimens may be detected in immature ones only as uncalcified or calcified cartilage. Also, the cartilaginous areas of articulations are proportionally much greater in the younger specimens.

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## Observations of Pelagic Fishes of the Tropical Atlantic<sup>1</sup>

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THE presence of research vessels of the Woods Hole Oceanographic Institution in the tropical Atlantic during much of the year 1952 afforded the opportunity for an incidental study of the pelagic fishes of the region. A hydrographic survey sponsored by the Office of Naval Research was carried out there in the winter and early spring by the ATLANTIS (cruise 178) and the ALBATROSS III (cruise A42). The authors, one aboard each vessel, devoted much of their spare time to collecting data on the pelagic fishes encountered. Carl Speight of the ATLANTIS' crew took a very keen and helpful interest in this work, and when this vessel returned to the area in August for cruises 180 (a geological study by the Lamont Observatory of Columbia University) and 181 (a hydrographic survey), he volunteered to continue the collection of pelagic fishes as an extra activity. With the assistance of others of the ships' companies and scientific parties, some very fine specimens were taken. These observations have been supplemented by similar ones recorded by Mather during passages of the ATLANTIS (cruise 151) from Bermuda to Gibraltar (Dec., 1947-Jan., 1948) and return (May-June, 1948). Although all

of these efforts had to be made to fit the exigencies of other work, nearly 80 observations were recorded.

Fishing was conducted chiefly by trolling, though all catches of sharks were made while the ships were hove to on stations. Trolling speeds averaged 8 knots for ATLANTIS and 12 knots for ALBATROSS III.

The locations of the observations are shown on the orientation chart (Fig. 1). For comparative purposes, we have divided the region into three areas, which are roughly based on hydrographic considerations. Area I is mainly in the Sargasso Sea, area II takes in the colder water near the African coast, while area III is in the equatorial current system.

All observations are arranged according to species (Table I), and numbers are used to designate the respective observations on the chart and in the text. Sharks were measured from the snout to the tip of the upper caudal lobe; teleostean fishes from snout to fork of tail. Figures in parentheses are estimates. Observations from which specimens or skeletons with head and fins were preserved are marked with an asterisk (\*). During cruises 180 and 181, no consistent record of fish lost or sighted was kept.

<sup>1</sup> Contribution No. 651 from the Woods Hole Oceanographic Institution.

## THE OBSERVATIONS CONSIDERED BY SPECIES

A discussion of some of the species observed, with emphasis on what appear to be unusual or little-known occurrences, is presented below. Wherever temperature preferences appear probable, mention is made of them. The three areas are compared for general productivity of potentially valuable fish.

ture of a great barracuda over 270 miles from the nearest shoal water (observation 21) was of interest because this species is generally believed to frequent reefs or banks and to wander only relatively short distances out into deep water. Other offshore records of this species obtained from the ATLANTIS include three individuals taken by Harold Backus at

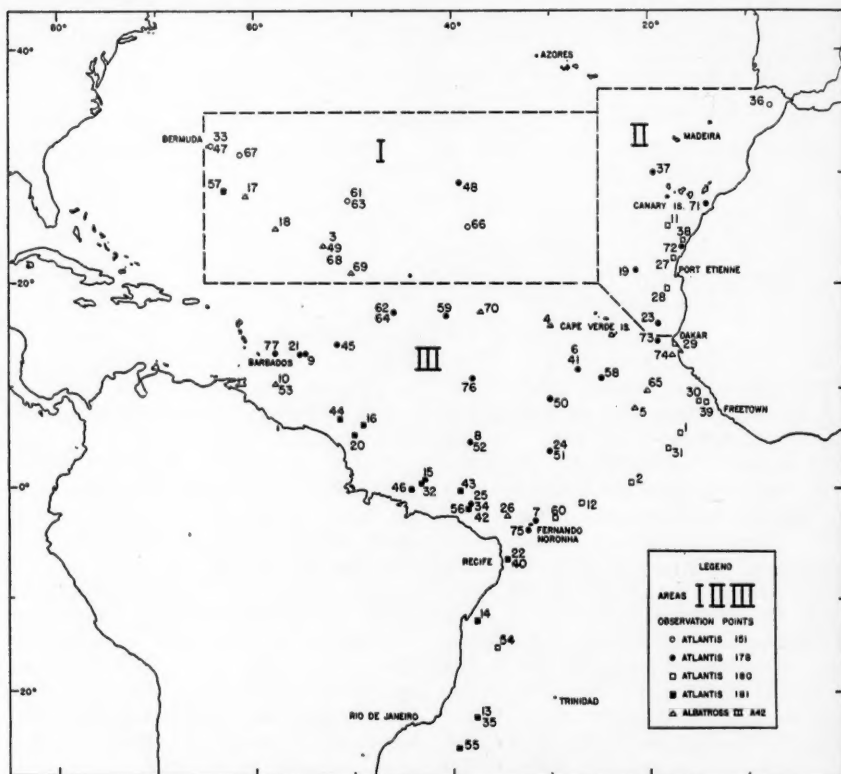


Fig. 1. Orientation chart of cruises of the ATLANTIS and the ALBATROSS III

*Carcharhinus longimanus* (Poey): The white-tipped shark was by far the most abundant and widely distributed pelagic shark in the area. Sixteen were caught and about 16 others were seen, while only three sharks of all other species combined were taken. The recorded occurrences of white-tipped sharks were in temperatures ranging from 72.6° to 82.4° F. They were taken in all three areas, but were most common in area III.

*Sphyrna barracuda* (Walbaum): The cap-

ture of the Brownson Deep, about 80 miles north of Mona Passage in March, 1949, and one taken September 11, 1953, at 38°16' N and 69°10' W, about 280 miles south of Cape Cod.

*Katsuwonus pelamis* (Linnaeus): Although the oceanic bonito or skipjack is one of the mainstays of the high seas tuna fishery of the Pacific, we found no indication that it is comparably abundant in the Atlantic. A single rather large specimen (observation 24) was taken in mid-ocean, but the only schools

TABLE I  
LIST OF OBSERVATIONS

Observation No.	Species	Caught	Lost	Sighted	Length in cm.	Month	Lat.	Long.	Surf temp. °F
1	<i>Prionace glauca</i>	1			(250)	Sep. '52	5°23'N	17°00'W	80.6
2	(Great blue shark)	1			(300)	Sep. '52	0°35'N	21°35'W	77.0
3	<i>Carcharhinus longimanus</i>	1	1			Feb. '52	23°28'N	53°01'W	75.5
4	(White-tipped shark)	1				Feb. '52	15°56'N	30°03'W	72.6
5				1	(150)	Feb. '52	7°50'N	21°26'W	78.7
6		1			166	Mar. '52	11°48'N	27°10'W	74.1
7			1	1	(175)	Mar. '52	3°17'S	31°37'W	82.4
8		2		1-2	156-163	Mar. '52	4°37'N	38°09'W	80.0
9			1		(165)	Apr. '52	13°17'N	54°57'W	80.1
10		2	1	(7)		Apr. '52	10°17'N	57°53'W	80.9
11		1			(240)	Aug. '52	25°18'N	18°04'W	73.4
12		1			(155)	Sep. '52	1°27'S	26°51'W	78.0
13		1				Oct. '52	22°21'S	37°39'W	74.5
14		1				Oct. '52	13°03'S	37°30'W	79.8
15		3				Nov. '52	0°49'N	42°46'W	81.8
16		2				Nov. '52	6°12'N	48°58'W	81.6
17	Unidentified shark			1	(Large)	Feb. '52	27°51'N	60°51'W	62.0
18				1	(Large)	Feb. '52	25°05'N	57°50'W	74.5
19				1		Feb. '52	21°12'N	21°16'W	66.4
20		1			60	Nov. '52	5°20'N	49°53'W	81.4
21	<i>Sphyræna barracuda</i>	1			107	Apr. '52	13°19'N	55°25'W	80.4
22*	(Great barracuda)	1			70	Oct. '52	7°00'S	34°30'W	79.6
23	<i>Katsuwonus pelamis</i>	2	5		46-48	Feb. '52	16°17'N	19°08'W	67.2
24*	(Oceanic bonito)	1			72	Mar. '52	3°34'N	30°11'W	81.7
25*	<i>Euthynnus alletteratus</i>	2			63-67	Mar. '52	1°35'S	38°10'W	83.1
	(Little tuna)								
26	<i>Neothunnus albacares</i>			(100)	(220)	Mar. '52	2°44'S	34°33'W	82.6
27*	(Yellowfin tuna) (a)	3			59	Aug. '52	22°13'N	17°27'W	68.3
28	(a)	3				Aug. '52	19°26'N	18°06'W	79.7
29	(a)	1				Aug. '52	14°39'N	17°20'W	
30	(a)	2				Sep. '52	8°47'N	14°57'W	79.8
31*		1	1		143	Sep. '52	4°00'N	18°00'W	80.1
32				(1500)	(100)	Nov. '52	0°32'N	43°15'W	81.0
33	<i>Parathunnus atlanticus</i>	1			50	Jun. '48	32°21'N	64°37'W	76.2
34*	(Blackfin tuna)	5	1		61-78	Mar. '52	1°35'S	38°10'W	83.1
35*		1			71	Oct. '52	22°21'S	37°37'W	74.5
36*	<i>Thunnus thynnus</i>	1			52	Jan. '48	35°40'N	7°48'W	63.6
	(Bluefin tuna)								

TABLE I (Continued)

Observation Nos.	Species	Caught	Lost	Sighted	Length in cm.	Month	Lat.	Long.	Surf temp., °F.
37	<i>Thunnus</i> sp. (b) (Unidentified tuna)		1		(40)	Feb. '52	30°05'N	19°34'W	64.5
38*	<i>Sarda sarda</i> (Atlantic bonito)	1			41	Aug. '52	24°02'N	16°28'W	67.5
39*	<i>Scomberomorus maculatus</i> (Spanish mackerel)	1			54	Sep. '52	8°22'N	14°06'W	79.5
40	<i>Scomberomorus cavalla</i> (King mackerel)	1				Oct. '52	7°00'S	34°29'W	79.6
41*	<i>Acanthocybium solandri</i> (Wahoo)	1			162	Mar. '52	11°48'N	27°10'W	74.1
42*		1			144	Mar. '52	1°35'S	38°10'W	83.1
43*		1			126	Nov. '52	0°19'S	39°16'W	80.0
44		1			140	Nov. '52	6°52'N	51°19'W	81.2
45*	<i>Gempylus serpens</i> (Snake mackerel)	1			100	Apr. '52	14°08'N	51°37'W	79.0
46	<i>Makaira nigricans</i> <i>ample</i> (Blue marlin) (c)	1			250	Nov. '52	0°08'S	44°10'W	80.2
47	<i>Seriola falcata</i> (Falcate amberjack)	1			57	Dec. '47	32°21'N	64°37'W	68.9
48	<i>Coryphaena hippurus</i> (Common dolphin)	1			79	Feb. '52	29°04'N	39°19'W	70.8
49		2		(50)		Feb. '52	23°28'N	53°01'W	75.5
50				(5)	(60)	Mar. '52	8°42'N	29°57'W	75.0
51			1		(90)	Mar. '52	3°34'N	30°11'W	81.7
52				(100)	(75-100)	Mar. '52	4°37'N	38°09'W	81.0
53				(12)	(75)	Apr. '52	10°17'N	57°53'W	80.9
54		2			86-137	Sep. '52	15°41'S	35°27'W	78.0
55		1				Oct. '52	25°08'S	39°26'W	70.8
56		1			(Large)	Nov. '52	2°01'S	38°29'W	79.8
57		1			61	Dec. '52	28°22'N	63°05'W	74.9
58	<i>Coryphaena equisetis</i> (Little dolphin)	1			30	Feb. '52	10°57'N	24°45'W	75.9
59		1			43	Mar. '52	16°58'N	40°38'W	75.9
60*		6			46	Sep. '52	2°54'S	29°39'W	78.2
61	<i>Coryphaena</i> sp. (Unidentified dolphin)			1-2	(Small)	Jun. '48	27°26'N	50°23'W	77.0
62				1	(35)	Apr. '52	17°19'N	45°51'W	78.3
63	Unidentified triggerfish	(10)		(100)	(35)	Jun. '48	27°26'N	50°23'W	77.0
64				(20)	(35)	Apr. '52	17°19'N	45°51'W	78.3

\* Specimen  
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TABLE I (Continued)

Observation No.	Species	Caught	Lost	Sighted	Length in cm.	Month	Lat.	Long.	Surf. temp., °F
65	<i>Mola mola</i> (Ocean sunfish)			1	(200)	Feb. '52	9°40'N	20°03'W	76.6
66	Unidentified fishes		1		?	Jun. '48	25°11'N	38°22'W	74.3
67			1		(Large)	Jun. '48	31°25'N	61°27'W	77.5
68			1		(Large)	Feb. '52	23°28'N	53°01'W	75.5
69			1		(Med.)	Feb. '52	20°56'N	50°17'W	75.7
70			1		(Large)	Feb. '52	17°15'N	37°17'W	74.3
71			1		(75)	Feb. '52	27°11'N	14°09'W	63.9
72			1		(Large)	Feb. '52	23°18'N	16°45'W	66.2
73			1		(Large)	Feb. '52	14°35'N	19°02'W	67.9
74	(e)			Many	(Large)	Feb. '52	13°15'N	17°40'W	65.±
75	(f)		2		(Large)	Mar. '52	4°08'S	32°20'W	82.3
76			2		(Large)	Mar. '52	10°51'N	37°52'W	78.1
77			1		(Large)	Apr. '52	13°07'N	57°56'W	80.5

\* Specimens or skeletons with head and fins were preserved.

(a) One specimen from observation 27 was preserved, measured, and identified. The others from observations 27-30 were reported to be of the same species and of about the same size as this specimen.

(b) Probably *Neothunnus albacares* or *Parathunnus obesus*.

(c) Measured from tip of bill to tip of caudal.

(d) One specimen was preserved, measured, and identified. The others were reported to be of the same species and of about the same size.

(e) Acres of bait chased by large fish.

(f) East of Fernando Noronha Island near this position about 7 areas densely covered by actively working sea birds were observed.

encountered were small ones found close to Dakar (observation 23).

*Parathunnus atlanticus* (Lesson): Observations made by us during and since these cruises, together with records from the literature, enable us to clarify and expand the picture of the distribution of this long neglected but important species. The blackfin tuna has rarely been recorded from waters south of the Caribbean. Beebe and Tee-Van (1936) showed that this was a valid species first figured and described by Lesson (1830) from Trinidad Island off Brazil (20° south latitude) as *Thynnus atlanticus*, and that Cuvier and Valenciennes described the same fish from Lesson's drawing as a new species, *Thynnus balleatus*. Prior to Beebe and Tee-Van's work most authors had placed these names in the synonymy of *Germo alalunga*, the true albacore of the eastern Atlantic and the Pacific.

The only other record we have found of the blackfin tuna from the southern Atlantic is based on the listing by Ribeiro (1915) of

*Germo alalunga* among the fishes of Brazil. Fowler (1941) used this record as it stood but in 1944 he placed it in the synonymy of *Parathunnus atlanticus*. Ribeiro's description, based on a specimen about 50 cm. long taken at Rio de Janeiro, is quite meager, and while some of the characters given apply to the blackfin tuna, others, such as the length of the pectoral fins in adults, definitely do not. On the basis of the published information, we would find it impossible to identify this specimen positively.

Our observation 35, made on an uncharted shoal off Brazil at 22° south latitude, gives positive confirmation of the occurrence of the blackfin tuna in this region, and substantiates the deductions of Beebe and Tee-Van concerning *Thynnus atlanticus* of Lesson.

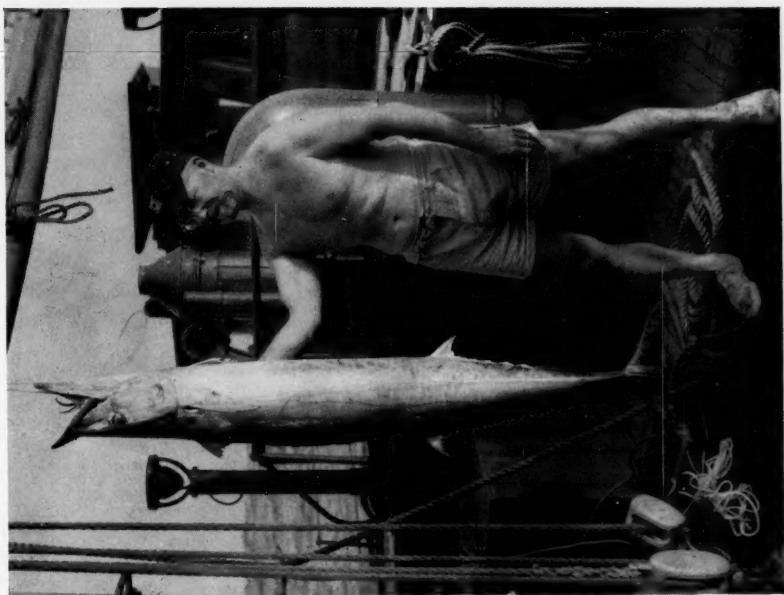
A blackfin tuna was seen by us in the market at Recife, Brazil, and 5 others were taken over a shoal off the north coast of that country (observation 34). Several specimens were seen in the market at Barbados. Thus it seems that

the species ranges along the coasts and among the outlying islands and banks from at least as far south as Rio de Janeiro to the Antilles. The species has been recorded throughout the West Indies as follows: from Haiti, by Beebe and Tee-Van (1928), as *Parathunnus obesus*; from the Grenadines, by Beebe and Hollister (1935); from Tobago, St. Lucia, and Grenada, by Beebe and Tee-Van (1936). Mendes and Whiteleather have told us of its presence off the north coast of Venezuela, and Fowler (1944) and Mather and Schuck (1952) have reported it from the western Caribbean. Stuart Springer, of the U. S. Fish & Wildlife Service, and J. L. Baughman (1950) have reported it from the Gulf of Mexico. We have seen specimens at Miami, Florida, where it was described by Fowler (1934) as *Parathunnus rosengarteni*, and in the Bahama Islands. We have also seen it at Bermuda, where it is very abundant and was first described by Mowbray (1935) as *Parathunnus ambiguus*. The northernmost limit of its ordinary range along the coast of the United States must be near Cape Hatteras, where a specimen was reported by Shuck and Mather (1951), and sixteen additional ones were identified by Mather in October, 1952. The northern record for the species is from off Martha's Vineyard, Massachusetts (Mather and Shuck, 1952). It does not appear to range very far outside the 100 fathom curve, though one was taken August 27, 1953, from the ATLANTIS at 35°54' N, 69°31' W, about 300 miles east of Cape Hatteras. Observations 34 and 35 were made over uncharted offshore banks. L. S. Mowbray has expressed the opinion that the Bermuda blackfins form a discrete population (Oceanic Fisheries Conference, Bermuda, June, 1951). The range of this species appears to be limited to the western Atlantic, and it occurs in area I only in the vicinity of Bermuda. It would be of interest, however, to compare individuals of this species with small specimens of the similar *Parathunnus obesus* (Lowe) of the eastern Atlantic.

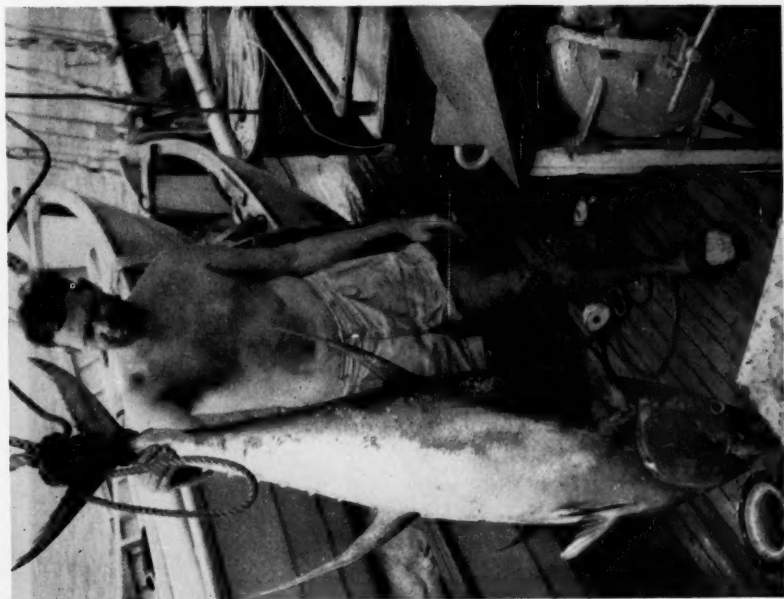
The commercial possibilities of the species appear to be worth consideration. The flesh is of excellent quality, comparable to yellowfin tuna. Mowbray reports a maximum size for the species of 60 lbs., but we have not seen any over 25 lbs. and most of the individuals we have examined weighed less than 10 lbs.

Therefore, the capture and processing of this fish would not be as difficult or expensive as is true of the larger tunas, an important consideration in undeveloped areas. The fact that the species schools densely should also be favorable to commercial fishing. A small tuna canning industry in western Cuba is supported by blackfin tuna and skipjack (Rawlings, 1953).

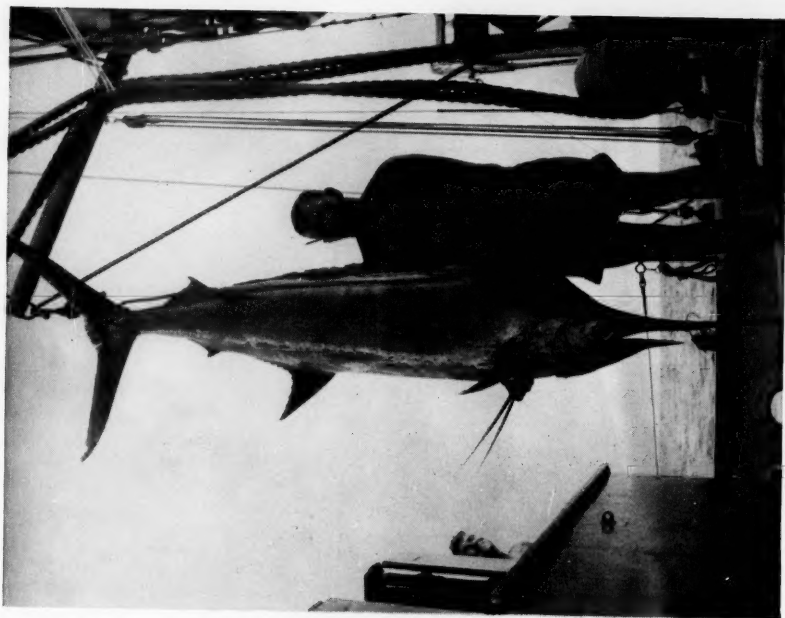
*Neothunnus albacares* (Bonnaterre): As the yellowfin tuna is perhaps the most important species taken in the high seas fishery of the Pacific, offshore records of it in the Atlantic such as our observations 26, 31 and 32 are of special interest. The specimen taken at 31 (Pl. I) was 143 cm. long, which corresponds to a weight of about 130 lbs. A similar fish parted a line at the same time. Those seen at observation 26 were especially large. They were playing on the surface close to the vessel and an observer who was very familiar with giant bluefin tuna estimated their weight at 400 lbs. That yellowfin tuna actually reach this great size has been confirmed by Mr. Dudley W. Wiles, Fishery Officer, Barbados, B.W.I., and by Mr. G. Blanche, Administrateur Principal de l'Inscription Maritime, Fort-de-France, Martinique, who have actually seen such fish brought in by commercial fishermen at their respective islands. Cunningham (1910) was told that the largest yellowfin tuna taken at St. Helena in the last few years before his visit weighed 400 lbs. Very large numbers of tuna believed to be yellowfins about 1 meter long were seen at observation 32. While these records are too few to justify drawing conclusions they are certainly sufficient to arouse a desire for further investigation. This is especially indicated as the U. S. Fish & Wildlife Service Laboratory at Honolulu has found that this species is abundant at convergences in the equatorial current system of the Pacific. There they are taken by long-line (deep) fishing and are seldom seen or caught on the surface. Our few efforts at deep fishing with single lines when the vessels were hove to were unsuccessful, but this is not surprising in view of the brief duration of these attempts and the limited number of lines used. The knowledge of the equatorial current system which is being gained should be of value in planning any future exploratory fishing. The yellowfin tuna were taken or seen over a



A wahoo, probably the first recorded from the eastern Atlantic (observation 41).



A 143-cm. yellowfin tuna taken 350 miles SW of Freetown, Sierra Leone (observation 31).



A 250-cm. blue marlin taken in the Guiana current off the coast of Brazil (observation 46).



A 100-cm. snake mackerel taken about 500 miles east of Barbados (observation 45).

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wide range of surface temperatures from 68.3° to 82.6° F. They appear to be especially abundant near the African coast.

*Scomberomorus maculatus* (Mitchill): The status of the Spanish mackerel of the eastern Atlantic is in question. Postel (1950), Cadenat (1950), Fraser-Brunner (1950), and Chabanaud and Monod (1926) listed it as a distinct species under the name *Cybius tritor* (Cuvier and Valenciennes, 1831). Fowler (1936) and Scaccini (1941) placed this name in the synonymy of *Scomberomorus maculatus* (Mitchill, 1815), and Smith (1949) and Lozano Cabo (1950) also applied the latter name to the West African fish.

While biometric and anatomical studies requiring many specimens would be necessary to settle this question definitively, we have made a preliminary effort with the material available (Table II). Two eastern Atlantic specimens (one from the Canary Islands at the Harvard Museum of Comparative Zoology and our specimen from observation 39) and seven Spanish mackerel from the western Caribbean and the Gulf of Mexico were measured, following the method of Marr and Schaefer (1949). The average measurements of 142 specimens from Dakar published by Postel (1950) were converted to this system. Counts published by Fowler (1936) from a small specimen taken off Liberia are also included. These data indicate the following differences between the seven specimens from the Caribbean and Gulf and those from the eastern Atlantic: (1) The second dorsal and ventral fins of 144 eastern Atlantic specimens were inserted more posteriorly (.515 and .26 of fork length, respectively) than those of the Caribbean and Gulf specimens (.50 and .25 of fork length, respectively); (2) The pectoral fins of 144 eastern Atlantic fish were longer (.136+ of fork length) than those of the latter fish (.125 of fork length); and (3) Three eastern Atlantic specimens had 16 or 17 first dorsal spines while the 7 Caribbean and Gulf fish had 17 or 18.

These slight differences appear to be racial rather than specific and until more important ones are shown we must consider the West African fish to be the same species as the American one, whose name, *Scomberomorus maculatus*, has priority. If the differences found were consistent in adequate series of

TABLE II  
MEASUREMENTS AND COUNTS OF  
*Scomberomorus maculatus*

Average measurements in percentage of fork length

Measurement	Locality and number of specimens			
	Gulf and Caribbean (7)	Sierra Leone (1)	Canary Islands (1)	Dakar (142)
Head length.....	.214	.222	.211	.205
Snout to 1st dorsal insertion.....	.250	.259	.255	.245
Snout to 2nd dorsal insertion.....	.502	.515	.513	.515
Snout to ventral insertion.....	.250	.276	.260	.260
Snout to anal insertion.....	.533	.530	.513	.532
Maximum depth....	.180*	.175	.177	...
Depth at 1st dorsal insertion.....	.150*	.161	...	.156†
Length of pectoral....	.125	.138	.144	.136
Length of maxillary..	.120	.125	.119	...
Length of snout.....	.088	.091	.088	...
Diameter of iris....	.035	.037	.029	...

#### Meristic characters

Character	Locality and number of specimens				
	Gulf and Caribbean (7)	Sierra Leone (1)	Canary Islands (1)	Liberia (1)	Dakar (142)
First dorsal spines	17-18	16	16	17	...
Dorsal finlets.....	8-9	9	9	8	7-9
Anal finlets.....	8-9	9	8	8	7-9
Upper gillrakers...	2-3	2-3	3	4	...
Lower gillrakers...	9-11	9-10	9-10	12	...

\* One Gulf of Mexico specimen much deeper than all the others was omitted.

† Average for June and October specimens. January specimens were much deeper and were believed to constitute a different population.

specimens from each region, it would show that at least two races of the species exist, one in the eastern Atlantic and one off the east coast of the Americas, and that there is little interchange between these populations.

*Acanthocybium solandri* (Cuvier and Valenciennes): The capture of a wahoo about 240 miles southwest of the Cape Verde Islands (observation 41; Pl. I) may afford new data on the distribution of this species. While it is common in the western Atlantic and in the

Caribbean, and a single capture has been reported from the Mediterranean, we have been unable to find any mention of wahoo from the Atlantic coast of Africa or the offshore islands. Tortonese (1939), in tabulating the worldwide distribution of the scombrids of the Mediterranean, excluded this species from the eastern Atlantic. This record shows that the species ranges well into the eastern part of the equatorial Atlantic.

The comprehensive lists of the fishes of Brazil compiled by Ribeiro (1918) and by Fowler (1941), as well as Tortonese's additions (1948) to the latter, do not include the wahoo. On the basis of three captures in the Guiana current area (observations 42-44), and of specimens seen by us in the markets of Recife, we can state positively that the wahoo is not uncommon off northern Brazil. Wahoo were taken in waters whose surface temperature ranged from 74.1° to 83.1° F.

*Gempylus serpens* Cuvier and Valenciennes: The taking of a snake mackerel on hook and line appears to be an unusual event. This one took a whole squid trolled at night (observation 45; Pl. II).

*Makaira nigricans ampla* (Poey): While marlins are frequently taken in the offshore waters of the Pacific by tuna fishermen using long lines, there is no corresponding fishery to provide information on their distribution in the Atlantic. The offshore capture of a blue marlin (observation 46; Pl. II) may therefore be of interest.

*Seriola falcata* Cuvier and Valenciennes: The falcate amberjack (Ginsburg, 1952), is especially abundant in Bermuda waters. The individual taken (observation 47) was caught close to St. David's Head and may be considered as belonging to the local fauna rather than to that of the open ocean.

*Coryphaena hippurus* Linnaeus: As the common dolphin is known to be widely distributed over the tropical oceans, it is not surprising that 8 of these fish were taken and about 120 more were sighted. They occurred over a very wide geographical range, but were not found in waters whose surface temperature was below 70° F. In the plankton-rich but relatively cold waters of area II off the African coast the dolphin was not found, although scombrids were hooked fairly frequently. This is in keeping with the findings

of Postel (1950), who reported that the dolphin was a rare fish on the West African coast, occurring only in the warm season and not in large schools. The dolphin was the only large pelagic fish other than sharks taken or seen in the offshore waters of area I, but was more abundant in area III.

*Coryphaena equisetis* Linnaeus: The less common little dolphin was taken on three occasions (observations 58-60) at widely separated offshore locations. It was found only in waters of area III whose surface temperature exceeded 75° F.

Unidentified fishes: In a number of instances, unidentified fishes were either hooked and lost or merely observed from aboard ship. Fish whose size is estimated as "large" were those which damaged heavy trolling gear. As gear which held a 162 cm. wahoo was parted on two occasions (observation 76), we can get some idea of the minimum size of these fish. Since our "large" fish struck at artificial lures being trolled at rather high speeds, tunas or very large wahoos would seem to be by far the most probable species.

Three separate attacks on scientific gear were made by unidentified marine animals. Because of the nature of the damage, the size of the animals must be estimated as large. At 2°21'N, 34°12'W, a bathythermograph was struck when at a depth of 695 feet in 2000 fm. of water. The fins on the tail of the instrument were deformed, but no scratches or tooth marks were evident. On two different occasions on the same day at approximately 13°00'N, 55°25'W. electrodes encased in a formica-canvas composition  $\frac{3}{8}$ " thick were attacked and destroyed. These electrodes were being towed well astern on 1000 lb. test cable at an estimated depth of 15 feet. When retrieved, one case was found to have been broken in half and the other showed deeply gouged tooth marks. At the time of these attacks the ship was making 12 knots.

#### THE OBSERVATIONS CONSIDERED BY AREAS

Table III summarizes the observations according to areas and species. Area I seems by far the poorest. The falcate amberjack and blackfin tuna appear to belong to the local fauna of Bermuda rather than to that of the oceanic area. Thus the common dolphin was the only fish of any value taken or seen in the offshore waters. Four unidentified fish were

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lost in this area, and two of these were considered to be large. The fishing was not notably better in May and June than it was in the winter months.

Area II is quite rich in scombrid fishes. Four valuable species were taken, and another, the little tuna, or false albacore, *Euthynnus alletteratus* (Rafinesque) was seen in quantity at the Dakar markets. Dolphin, however, were not observed in the area either in winter or summer. The fishing, especially for the yellowfin tuna, appeared to be better in the summer than in the winter. This species was taken all along the West African coast from Port-Étienne to Freetown in the summer, and may well have accounted for gear damage sustained in the same area in the winter.

Area III produced the most fish and also the greatest variety of species. Seven species of scombrids were taken, and three of these, the yellowfin tuna, the skipjack, and the wahoo, were found in the deep offshore waters. The dolphins were also encountered frequently in the oceanic portions of the area. A total of 15 species was identified and at least two others were sighted. Seven unidentified fish were hooked and lost, and four of these appeared to be very large. The three attacks on scientific instruments also occurred in this area. The offshore shoals and islands usually showed evidences of good fishing, and the Guiana current seems to be a likely place for the larger game fish.

The data are rather meager for statistical treatment. We can estimate the trolling times for ATLANTIS cruises 151 and 178 only. To attempt to roughly assess the potentialities of the areas, we have considered only the scombrid fishes and dolphins, as the other species are either of no sport or commercial value or are not apt to occur pelagically in important numbers. Unidentified fishes which were hooked while trolling are included, as it seems very probable that they were either dolphins or scombrids. On this basis, we found that about 70 hours of trolling were required to hook a fish in area I, about 17 hours in area II, and about 15 hours in area III. If only the catches made in water over 100 fathoms deep are considered, the respective figures are approximately 94 hours for area I, 21 hours for area II, and 30 hours for area III. While it is recognized that the data are insufficient to afford a definitive comparison,

TABLE III  
SPECIES OBSERVED IN EACH AREA  
Figures in parentheses are estimates

Species	Number caught	Number lost	Number sighted
AREA I			
<i>Carcharhinus longimanus</i>	1	1	..
Unidentified shark	..	..	2
<i>Parathunnus atlanticus*</i>	1	..	..
<i>Seriola falcata*</i>	1	..	..
<i>Coryphaena hippurus</i>	4	..	(50)
<i>Coryphaena</i> sp.	..	..	1-2
Unidentified triggerfish	(10)	..	(100)
AREA II			
<i>Carcharhinus longimanus</i>	1	..	..
Unidentified shark	..	..	1
<i>Katsuwonus pelamis</i>	2	5	..
<i>Neothunnus albacares</i>	6	..	..
<i>Thunnus thynnus</i>	1	..	..
<i>Thunnus</i> sp.	..	1	..
<i>Sarda sarda*</i>	1	..	..
Unidentified fish*	..	2	..
AREA III			
<i>Prionace glauca</i>	2	..	..
<i>Carcharhinus longimanus</i>	14	3	(10)
<i>Sphyrna barracuda</i>	2	..	..
<i>Katsuwonus pelamis</i>	1	..	..
<i>Euthynnus alletteratus*</i>	2	..	..
<i>Neothunnus albacares</i>	4	1	(1600)
<i>Parathunnus atlanticus*</i>	6	1	..
<i>Scomberomorus maculatus*</i>	1	..	..
<i>Scomberomorus cavalla*</i>	1	..	..
<i>Acanthocybium solandri</i>	4	..	..
<i>Gempylus serpens</i>	1	..	..
<i>Makaira nigricans ampla</i>	1	..	..
<i>Coryphaena hippurus</i>	4	1	(117)
<i>Coryphaena equisetis</i>	8	..	..
<i>Coryphaena</i> sp.	..	..	1
Unidentified triggerfish	..	..	(20)
<i>Moia mola</i>	..	..	1
Unidentified fish	..	7	Many

\* These species were found only in shoal water.

this rough statistical presentation tends to confirm our previous estimates about the relative productivity of these areas.

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## Spawning and Behavior of the Longear Sunfish, *Lepomis megalotis megalotis*<sup>1</sup>

ARTHUR WITT, JR. AND RICHARD C. MARZOLF

THE spawning activities of the longear sunfish, *Lepomis megalotis megalotis* (Rafinesque), have been described only in a

general way, in spite of the common occurrence of this species. Breder (1936) summarized most of the pertinent literature for this sunfish

<sup>1</sup> Contribution from the Missouri Cooperative Wildlife Research Unit: U. S. Fish and Wildlife Service, Wildlife Management Institute, Missouri Conservation Commission,

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and other members of the family Centrarchidae. The behavior of the longear sunfish toward other fishes, under natural conditions, is even less completely known. Hankinson (1919) mentioned that this species is more active in defense of its nest than are the other sunfishes.

The writers witnessed the spawning and behavior of the longear sunfish between June 13 and 19, 1951, at the mouth of the Little Niangua River, Lake of the Ozarks, Missouri. Scattered nests in various stages of completion were noticed three days previous to the thirteenth. The average daily maximum and minimum water temperatures for this period were 77° and 74° F., respectively.

**NEST AND NESTING SITE.**—The nest which was observed most intensively lay on the north side of a small cove and was exposed to direct sunlight except during the early morning hours. It was 18 inches in diameter, slightly ovoid, 2 inches deep, and was built on a pebble bottom 4 feet from shore and in 10 inches of water. The center of the nest was composed of an 8-inch circle of chert pebbles, and finer materials were deposited toward its periphery until at the margin it was rimmed with a pronounced ring of silt.

Surrounding objects can best be located by superimposing the 12-hour clock on the nest. The writers were stationed on the north bank at 6 o'clock. Deep water was positioned at 12 o'clock. At 2 o'clock and 4 feet away in 1½ feet of water was a stump. At its base a second longear sunfish was making a nest which was only half completed. There was no surrounding shelter except for a dead branch at 4 o'clock which extended into the water for 2 feet.

**SPAWNING.**—At 9:35 AM the longear sunfishes were found in the act of spawning. The male, 4 inches long, was brilliantly colored, with orange predominating. The female, half his size, was olive drab. The male circled within the 8-inch center of the nest, always keeping the female between him and the center of the nest. They circled within the nest both clockwise and counter-clockwise, the direction dependent upon how the male reentered the nest after chasing an intruder. The male always remained in an upright position, while every 10 to 15 seconds the female would roll on her side, to within 20 degrees of the horizon, and bring her vent in close proximity to his. This posture

lasted only 2 seconds, during which time both fish shuddered, the female more violently than the male. This spawning posture apparently is common to the members of the family and is illustrated for the rock bass, *Ambloplites rupestris* (Rafinesque), by Breder (1936).

If another fish came within 2 feet of the nest while the male was circling, he would give chase immediately and then return to circle either in the same or opposite direction. When the male was absent from the nest the female made no effort to leave it. Abruptly at 9:50 AM, the male chased the female off the nest and as far as is known she made no effort to return.

Immediately after the female left, the male began to fan the nest. He maintained a normal attitude over the center of the nest while he moved his paired fins and caudal peduncle rapidly. He continued to fan the nest in this manner until 10:20 AM, leaving his task occasionally to chase intruders. The male then assumed a vertical attitude over the nest, standing on his tail. In this position he fanned the nest vigorously enough to dislodge small pebbles. He continued to alternate these methods of fanning until 10:50 AM, at which time observations were concluded for the first day.

It would appear that the first method of fanning would insure complete mixing of sperm and eggs and possibly clean the eggs of excess sperm. The second method of fanning would appear to drive the eggs deep into the interstices between the large pebbles, probably resulting in greater protection from predators.

**TERRITORIAL DEFENSE AND BEHAVIOR.**—A territory was established by the longear sunfish and it was vigorously defended during and after spawning from all, save one, intruder. Since there were only 2 nests on a comparatively large area, the territory of this one male was large, covering an area described by a 3-foot radius from the center of the nest. Recent observations of longear sunfishes nesting on a sand bar in the Maries River, Missouri, show that with increased numbers of breeders for a given area the size of the territory is reduced. Here the nests were placed on 2-foot centers which made them less than 1 foot apart. Hankinson (1919) reported groups of 5 to 13 nests which were only 1 to 12 inches apart.

During spawning, the behavior of the longear sunfish toward other fishes varied.

A small longear sunfish, apparently a female, repeatedly tried to invade the nest, but each time she was put to flight by the male. She was very persistent and was seen in the vicinity of the nest while the spawning act took place and for several days thereafter. It is possible that she was stimulated by the spawning pair to the point that she attempted to enter the nest and spawn. The longear sunfish with the incompleated nest at 2 o'clock approached the spawning pair and was immediately chased away. Fingerling *Micropterus salmoides* (Lacépède), *Notropis atherinoides* Rafinesque, *Lepomis macrochirus* Rafinesque, and other longear sunfishes were dealt with in a similar manner. In none of these defensive attacks was there actual physical contact, and no threatening posture was observed. Defense was accomplished by a sudden rush on the part of the defender and retreat by the intruder.

After spawning was completed, the longear sunfish exhibited the same general behavior but with several notable differences. On one occasion he approached the nest that was positioned at 2 o'clock and was himself chased back into his own territory. He continued to rout the small fishes mentioned above and also successfully put to flight a 6-inch *Micropterus salmoides*, which offered no resistance. The threatening posture was observed only once. It was displayed against the writers who apparently disturbed the fish. At this time the sunfish approached the shore with fins and opercles extended and mouth opened.

The behavior of the longear sunfish toward *Fundulus notatus* (Rafinesque) was quite different from that toward other fishes. Frequently groups of from 1 to 4 of these topminnows would pass over the sunfish's nest from either 3 or 9 o'clock. At no time did the sunfish attempt to chase them. If *Notropis atherinoides* or fingerling *Micropterus salmoides* passed in the same directions, and just beneath the surface of the water, the sunfish gave chase. Thus, *Lepomis megalotis* apparently did not defend against surface-feeding fishes, but rather against those that may feed from the bottom.

On the second day the writers witnessed two unusual acts of behavior on the part of the

longear sunfish. The male defended against the usual small fishes and against the persistent encroachment of what appeared to be the small female which was present on the preceding day. On two occasions he defended his nest against 3 *Ictiobus bubalus* (Rafinesque) that were approximately 14 inches long. The first encounter was with a single individual which approached the nest from 11 o'clock. The sunfish darted for the intruder which was rapidly turned away. On the second encounter a pair of smallmouth buffalo approached from the same direction and they were turned away as rapidly as was the single individual.

Soon after this, a large *Micropterus salmoides* was observed in the deep water of the cove. It was approximately 18 inches long and capable of devouring the longear sunfish. The largemouth bass approached the nest from 11 o'clock. For an instant the sunfish turned toward the direction of the intruder as if to challenge him and then abruptly turned and fled, seeking the meager cover offered by the small dead branch at 4 o'clock. The largemouth bass approached the nest and then swam back into deep water. Within 15 seconds the longear sunfish had returned to his nest.

From this behavior it could be inferred that the longear sunfish is able to recognize differences in form between predacious and non-predacious fishes, much as birds are able to differentiate between silhouettes of predacious and non-predacious birds (Tinbergen, 1951).

The longear sunfish was observed fanning his nest both day and night for the next few days until a rapid rise in the water level of the reservoir accompanied by increasing turbidity precluded all possibility of further observation.

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# The Frequency Range of Mechanical Vibrations Perceived by Three Species of Freshwater Fish<sup>1</sup>

GAYLORD E. ROUGH

CONSIDERING the sounds which are a normal part of the environment of fishes, the extent of the range of frequency perceived, as reported in previous investigations, seems narrow. An attempt has therefore been made to determine more fully and accurately the limits of perception of some common freshwater fishes. In the literature there seems to be little doubt at present that fishes do possess the ability to perceive sound. Greater disagreement lies in the question of limits of perception, especially in the higher frequencies.

Parker and Van Heusen (1917a) found that *Ameiurus* responded to frequencies of four to five double vibrations (d. v.) per second. Rode (1927) reported similar results. The lower limit of response of *Phoxinus laevis* was found by von Frisch (1936) to be between 16 and 32 d. v. per second. Parker and Van Heusen (1917b) found that eight species of fish responded by gill and fin movements to higher frequencies up to 688 d. v. per second, with best results from *Ameiurus*. Manning (1924) observed similar responses in the goldfish (*Carassius auratus*), up to 2752 d. v. per second. Stetter (1929) reported results on five species of fish as follows: *Phoxinus laevis*, 4645 to 6960 d. v.; *Idus melanotus*, 5524 d. v.; *Carassius auratus*, 3480 d. v.; *Cobitis barbatula*, 1740 to 3480 d. v.; and *Ameiurus nebulosus*, higher than 13,139 d. v.

Von Bouteville (1935) found that the upper limits of tone perception for characids lies above 6960 d. v. Von Frisch (1936) stated that both the upper and lower limits of tonal perception in fishes that have a well-developed capacity for hearing is approximately the same as in man. Stephens and Bate (1950), though offering no experimental proof, are of the opinion that the range of hearing possibly includes all sounds in the environment from a frequency of four or five d. v. per second caused by the body movements of the fish themselves, to the supersonic vibrations caused by bursting bubbles.

## METHODS AND APPARATUS

In the present study it was decided to employ the learning or conditioning method as previously used by Froloff (1925), Bull (1928), and others, but with several new techniques and apparatus which were believed necessary to correct the inadequacies of previous studies.

The subject was placed in the testing aquarium and was allowed to remain there permanently to avoid experimental errors which might be induced by a sudden change of environmental conditions. During the conditioning process, sound of given frequency—the conditioned stimulus—was introduced beneath the surface of the water of the aquarium, followed after an interval by shock—the unconditioned stimulus—of sufficient intensity to cause active swimming. The sound was terminated with the shock stimulus. It was anticipated that a conditioned response would be induced to the extent that whenever sound was perceived by the subject, active swimming would result before shock was given. If active swimming did result, the shock was withheld as a "reward." The sound-shock routine was repeated at intervals of not less than once a minute until a consistent positive response to the conditioning stimulus resulted.

The active swimming response was preferred over the fin, opercular, or other body movements of minor degree such as were used by Parker, Froloff, Bull, Westerfield (1922), and others, as a more difficult criterion for perception of sound, thus tending to make interpretation of reaction more positive and conclusive.

Once the conditioned response was established satisfactorily, the frequency of sound was changed gradually, a few cycles at a time, to prevent discrimination of tones, and to determine if all frequencies were perceived, until the limit of perception at one end of the frequency range was obtained. The frequency was then shifted back to, or close to, the conditioning frequency, and from there the sound was gradually changed toward the other end of the frequency scale, thus determining the

<sup>1</sup> Contribution No. 4, Pymatuning Laboratory of Field Biology, University of Pittsburgh.

upper and lower limits of perception. The degree of positive response was recorded as the percentage positive reactions in ten trials.

The testing aquarium was of 20-gallon capacity, 14 inches high, 12.5 inches wide, and 36 inches long, with glass sides, ends, and bottom, all of which were painted black on the outside surfaces. A bed lamp was suspended on the inside at one end of the aquarium to illuminate the interior. A cardboard shield with an observation aperture of one-inch diameter was fitted to the top.

The sound source was a variable frequency oscillator designed and assembled by Mr. Eskil Karlson of E. I. DuPont DeNemours and Co. It provided pure tones of frequencies varying gradually from approximately one cycle per second to a point much above the range of human hearing; however, the upper range was calibrated only to the 22,000 cycle point. The source of audible output was one unit of a headphone set which was waterproofed and suspended midway between the surface of the water and the bottom at one end of the aquarium, with the diaphragm facing the opposite end of the aquarium. The other phone unit was left in series with the waterproofed unit and was used as a monitor to provide a constant check on the characteristics of the stimulus. The control for the sound output was a potentiometer mounted on the front panel of the oscillator, which increased the sound from zero to maximum intensity. No provision was made to measure the sound intensity in decibels, so it was advanced from zero to maximum at all frequencies and during every trial.

A provision to supply an electrical shock of momentary duration was also included, and was controlled by a rotary switch on the front panel which activated a relay. From the shock output an insulated wire led to a copper positive plate suspended in the water at one end of the aquarium, and from a point on the chassis of the oscillator a similar wire led to a negative plate suspended at the opposite end of the aquarium. The effective voltage was variable according to the body mass of the fish and to the extent to which the electrodes were suspended in the water. The plates were therefore adjusted to the point at which the voltage was merely great enough to cause the subject to swim actively.

Unwanted visual cues were eliminated by the

opaque nature of the aquarium and by the cardboard shield with the small observation hole. If experimentation was carried on in a darkened room with only the interior of the aquarium illuminated and with no light falling upon the experimenter, the shield was found to be unnecessary, so it was used only during lighted conditions. Mechanical stimuli were eliminated by placing the oscillator on a high stool several inches from the table on which the aquarium stood. Both the table and the stool stood on the vibration-free concrete floor of the laboratory. Care was taken to avoid touching the table or the aquarium during experimentation.

#### SUMMARY OF RESULTS

The first subjects examined were two central mudminnows, *Umbra limi* (Kirtland) 2.50 inches and 2.25 inches in total length, respectively. On the larger individual a conditioning frequency of 350 cycles, which is within the range of perception of this species (as reported by Westerfield, 1922), was used. Within seven days a total of 90 trials were completed. The only positive responses noted were the normal responses to shock, except on the 76th trial when swimming occurred very soon after the vibratory stimulus, and before shock. It is probable that this reaction was coincidental and therefore insignificant. The smaller mudminnow was subjected to the same system of training, but at a frequency of 910 cycles. During 150 trials extended over a period of eight days there were no responses which could be interpreted as definitely positive, though three trials were questionable.

The second species subjected to training was the brown bullhead, *Ameiurus nebulosus* (LeSueur), and included two specimens. The first of these was 4.0 inches long. After a period of adjustment to the environment of the aquarium, conditioning was begun, using as the conditioned stimulus a frequency of 910 cycles. Unlike the mudminnows which showed no definite reaction to sound, the bullhead appeared to respond almost from the beginning by a slight decrease of opercular movement in frequency and degree. The opercular response was not the result of conditioning; it was not regarded as significant in the study. Conditioning did not begin until around the 90th trial. Even then, the positive responses were

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very scattered and not generally consistent, although when positive responses did occur they appeared to be motivated by a definite association of the sound with shock. This was evident from the observation that the swimming response was of the same nature as the usual response which followed shock—that is, an attempt to escape from an unpleasant sensation, characterized by vigorous movements of the caudal fin. Conditioning continued to increase until around the 200th trial. Thereafter a decline in responses followed, and two days later the subject died. The unknown factors which caused the death of the subject presumably were responsible for the decrease of responses before death. A second specimen of the same size failed to develop a consistent pattern of response. After the 50th trial this subject also died.

The training of a young carp, *Cyprinus carpio*, four inches long was begun with the same procedure that was used for the bullheads, including the same frequency of 910 cycles. Unlike the bullheads and the mudminnows, which settled to a quiescent state within a minute after shock, the carp remained in motion for usually three to five minutes, and appeared to react more readily to any visible movements of the experimenter or to any jarring or movements of the aquarium or the table on which it stood. As a result, extreme care was taken to avoid those harmful interfering stimuli.

The first suggestion of a positive reaction was observed with the 17th trial and again with the 31st, 44th, and 49th trials. After the 40th trial the reactions were never less than 10 percent positive. Beginning with the 140th trial, a general trend toward increasing positive reactions was evident, and after the 170th trial, all conditioning trials averaged 50 percent positive or greater, so the conditioned response to sound was probably well established. Beginning with the 210th trial the process of changing the frequency of sound was initiated. The positive response remained consistently positive with less than 40 percent negative reaction throughout the remainder of the trials, except during the interval between the 240th and 260th trials, when the negative responses averaged 50 percent. No apparent reason could be determined for this slight decrease of responsiveness. The range of frequency covered

by this interval was 1180 to 1250 cycles. Whether or not a relationship is suggested between this range and the decrease of responsiveness could not be determined with certainty.

In all such instances throughout the study when negative responses were interspersed with positive responses, the frequency was not again changed until two consecutive positive responses were obtained following a negative response. In all, a total of 330 trials were completed, the series being terminated with the death of the subject due to inroads of fungus infection. A range of 3,290 cycles, from 910 to 4200, had been covered completely with no appreciable breaks in perception and response.

The second carp subjected to training measured 5.0 inches long. The same procedure as described above was employed, as well as the same initial conditioning frequency, 910 cycles. The conditioning pattern followed that of the first carp quite closely. Conditioning of the second was considered to have reached a sufficient degree by the 140th trial, however, in contrast to the 210th for the first. At this point the gradual decrease in sound frequency was begun as the trials were continued.

Response was generally consistent with no appreciable gaps until the frequency of 71 cycles was used. Likewise, the negative response was greater for 61 and 55 cycles. That the responses were predominately positive between these stages, showing an inconsistency, would indicate that either these frequencies were not as well perceived, or, more likely, they were merely chance variations. Response was predominately positive from there on until the stimulus was 17 cycles, or after the 750th trial. In the next 20 trials in which the frequency was reduced to 14 cycles, the response dropped to zero percent, but when the frequency was increased again to 17 cycles, response increased. On this occasion it was also observed that the quality and intensity of the sound at the lower frequency was much below average, so adjustments were made on the oscillator to correct the condition. Thereafter responses became slightly more positive. Nevertheless, as the frequency was further decreased to eight cycles, the average positive response approached 50 percent. No further decreases in frequency were made as the tones produced below eight cycles were no longer pure.

The frequency was then shifted to 2100

cycles. A 20 percent positive reaction at 20 trials, 50 percent at 30 trials, and a 70 percent positive reaction at 40 trials was obtained. This rapid degree of learning suggested that previous training increased the ability of the subject to learn to respond to a new frequency widely separated from the first. All reactions were better than 70 percent positive from 2100 cycles to 6500 cycles. This range was covered in only 60 trials since at the higher frequency ranges each minor division of the frequency dial of the oscillator denoted a much greater frequency change than at the lower ranges. In other words, though one dial unit at 500 cycles denoted a change of 25 cycles, each unit at 2200 cycles and above denoted a frequency change of 100 cycles or more. It was therefore logical to conclude that the subject's degree of discrimination between tones of different frequencies, at least differing no greater than 100 cycles, was not great. Whether or not the carp had the ability to learn to discriminate between tone differences of that magnitude was not determined. After the 1000th trial, at which time the frequency of sound was 6500 cycles, response dropped to zero percent at 7200 cycles. It rose to 20 percent after 10 more trials and with the sound stimulus at a frequency of 8500 cycles. In the remaining 40 trials positive responses were obtained not less than 70 percent of the time to the remaining frequencies up to 22,000 cycles, the highest point for which the oscillator was calibrated.

#### CONCLUSIONS

It was not possible to develop a conditioned response to vibratory stimuli in *Umbra limi* because of the inability of this species to perceive the stimuli, or its inability to form associations. The range of perception could therefore not be determined by the method of conditioning with active swimming as the criterion for positive response.

A conditioned response was developed in *Ameiurus nebulosus*, but because of a high rate of mortality among the subjects a determination of the range of perception of vibratory stimuli was not completed. This species was capable of perceiving vibrations of 910 cycles with certainty.

*Cyprinus carpio* demonstrated the ability to

form a strong, lasting association of vibratory stimuli with shock, and ability to respond in a consistent manner to these vibrations. These greater abilities of the carp in contrast to the apparent abilities of the mudminnow and the bullhead might indicate that either the carp has more efficient receptors for vibratory stimuli, or its ability to form conditioned responses is greater.

The perception of *Cyprinus carpio* was found to be effective within the frequency range of eight to 22,000 cycles without any discreet points of greater or lesser sensitivity. It is possible that the perception of this species extends much further into the range of super-sonic vibrations.

Further studies are being planned using a greater number of subjects of several species, and including comparative studies of the perceptive ability of various age and taxonomic groups.

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# The Pushnet, a One-man Net For Collecting in Attached Vegetation

KIRK STRAWN

THE pushnet, apparently unknown to most ichthyologists, is an efficient one-man net for collecting in shallow water and in attached aquatic vegetation, including cattails. Its operation (Plate I) is identical to that of a man-powered lawn mower, with the same ease of control and maneuverability. It operates much like a trawl but can be used in shallower water and its course is easier to control. A seine dragged in heavy vegetation tends to ride high off the bottom and to roll up, whereas the leading edge of a pushnet in the same situation stays on the bottom and the webbing remains fully spread from the start to the end of a "push." Operating a pushnet in heavy vegetation is much less fatiguing than using a seine.

To demonstrate the superiority of a pushnet over a seine for collecting weed-inhabiting fish, a roller pushnet was used simultaneously with a 6-foot common-sense minnow seine on two stations, for a 20-minute period on each, in the San Marcos River, Hays County, Texas, on June 22, 1952. The roller pushnet (Fig. 1) was 4 feet wide and 40 inches from top to bottom, with a very shallow bag of  $\frac{3}{8}$ -inch stretched mesh netting. Clark Lubbs and George G. Henderson, Jr., used the seine and I pushed the pushnet. The time taken to preserve the fish was included in the 20-minute periods.

The first station, a fast riffle, had a heavy growth of *Vallisneria*, a gravel bottom, and a depth of 6 inches to 2 feet. Fish caught in the pushnet and seine, respectively, were: shiners 0-5, catfishes 185-70, gambusia 17-30, darters 155-28, sunfishes 15-6, and cichlids 2-0. The second station, in relatively slow current just downstream from the first, was 1 to 2 feet deep with a dense cover of *Vallisneria* on a muddy bottom. The respective catches of the pushnet and seine here were: catfishes 21-0, gambusia 3-8, darters 20-2, sunfishes 69-24, and cichlids 6-2. The sizes of fish caught by the two methods were similar. The pushnet catch-per-worker was more than 5 times that of the seine in the fast, vegetated riffle, and more than 6.5 times

that in the slower water. The efficiency of the pushnet is even more striking if only that part of the 20-minute period spent netting fish is compared, for at the first station I used more time to preserve 374 fish than the two seiners did to preserve 139 fish. The pushnet was superior for catching catfishes (*Ameiurus*, *Schilbeodes*), darters (*Etheostoma fonticola*), sunfishes (*Lepomis*, *Ambloplites*), and the cichlid (*Cichlasoma c. cyanoguttatum*) that easily escape under a seine used in vegetation. Per worker the two nets caught somewhat similar numbers of the surface-living gambusia, and the seine was superior for the fast-swimming shiners (*Notropis amabilis* and *N. lutrensis*).

Over 150 days of collecting on the shallow water "grass flats" of the Gulf Coast have demonstrated the value of the pushnet for collecting pipefishes, seahorses, gobies, blennies, and a toadfish, as well as small serranids, snappers, haemulids, sciaenids, trunkfishes, swellfishes, and flatfishes. The "grass flats" are areas of slight relief vegetated with one or more of the following: *Cymodocea manatorum*, *Halodule wrightii*, *Ruppia maritima*, *Halophila engelmanni*, and *Thalassia testudinum*. Surface dwelling marine fish were rarely caught.

**TYPES OF PUSHNETS.**—A beveled board, a roller, or runners are used on the front edge of pushnets. A beveled board net is used by bait-shrimp fishermen in the Mosquito Lagoon area south of New Smyrna Beach, Florida. Two cross pieces of 1 × 3 inch cypress 6 to 8 feet long are attached to a handle 8 or 10 feet long which in width is either 1 × 4 inches or 2 × 2 inches. One cross piece is attached to the front end of the handle and the other is attached 3 to 4 feet back. The front cross piece is attached at about a 20-degree angle and its leading edge is beveled to facilitate its sliding on the bottom. The bag is made by stringing 1-inch stretched mesh netting, 150 meshes deep, on a line and attaching the line to the cross pieces. The line supports the netting between the ends of the cross pieces. The side

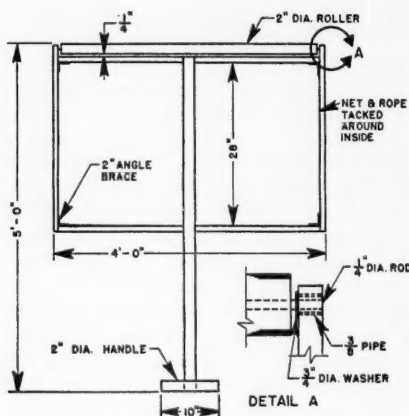


Fig. 1. A roller pushnet

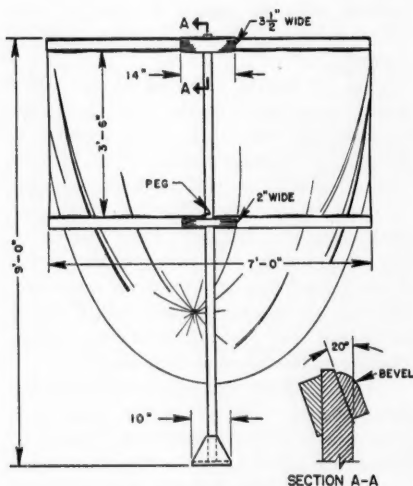


Fig. 2. A beveled board pushnet

of the bag is sewed up and the bottom of the bag is closed by bunching the net on a cord woven through the selvage. The contents of the net are dumped in the bottom of the boat and the shrimp separated. In 1948, most of the nets in the Lagoon area were about 4 feet wide. The difficulty of carrying the rigid 6- to 8-foot-wide nets now in use in a skiff prompted the construction of collapsible nets. One such net (Fig. 2) made by George W. McNolt of Oak Hill, Florida, has a  $2 \times 2$  inch handle fitted into a shoe on the front cross piece and through

a collar on the rear cross piece. A peg inserted into the handle keeps the rear cross piece from sliding forward. This net is taken apart and rolled into a cylindrical bundle or assembled ready for use in about 30 seconds.

I have used a modified beveled board net (Plate I) for collecting seahorses and pipefishes. In place of cord small boards are used between the ends of the cross pieces. These make the net more rigid and help to keep fish from swimming over the sides. This is especially true when the net is allowed to float on the surface of the water when seahorses are removed. The frame is fitted with a deep scoop-shaped bag of  $\frac{3}{8}$ -inch stretched mesh netting. The fish are kept close to the surface of the water by pulling the netting tight across the rear cross piece.

In the Tampa Bay area of Florida, commercial bait-shrimp and dwarf seahorse fishermen<sup>1</sup> construct a roller net (Fig. 1) using a roller made of wooden round or metal tubing  $1\frac{3}{4}$  to 2 inches in diameter. The roller is formed of one piece or is divided in the center. (A long wooden roller may bow instead of roll when the net is pushed.) The cross pieces, usually 4 to 5 feet long, are placed 20 or 30 inches apart on a 5- to  $5\frac{1}{2}$ -foot handle. The outer ends of the cross pieces are joined by boards which project in front of the anterior cross piece and support the roller. A bearing made of metal tubing is embedded in this anterior projection and a shaft made of a galvanized nail or bolt is partly embedded in the end of the roller or vice versa. A net with a divided roller is constructed with the handle protruding beyond the front cross piece to form a support for the inner ends of the rollers. The net shown in Figure 1 can be converted into a collapsible roller net by attaching a roller to the front cross piece with metal angles. A rectangular piece of  $\frac{1}{2}$ -inch stretched mesh netting is stretched across the frame. The very shallow bag is formed by a slight sag in the netting. The net is held above the water while the contents are being examined. The small size of the net enables a fisherman to support it with one hand and to reach all parts of the net with the other hand. Some fishermen use a hinged leg, fastened to the

<sup>1</sup> The dwarf seahorses, *Hippocampus zosterae* Jordan and Gilbert, are preserved, dried, and sold to shell dealers for \$15.00 to \$25.00 per 1,000.

# KIRK STRAWN—THE PUSHNET

PLATE I



*Upper:* A beveled board pushnet with a deep bag.  
*Lower:* A shallow-bag roller pushnet in use.

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handle a few inches back from the front cross piece, to support the net while the catch is being removed.

The roller pushnet and the beveled board pushnet each have certain advantages. The roller pushnet does not require as long a handle and is much easier to push. It can be successfully used around oyster bars and rocky areas, while the beveled board net requires an obstacle-free bottom. In heavy growths of marine algae the roller net rolls over most of the algae while a beveled board net scoops up the algae and is soon clogged. The beveled board net is probably somewhat better for digging flatfishes out of the bottom and for scraping seahorses off the vegetation. It can be used in shallower water than the roller net. Water that is knee-deep is best for both nets although they can be used from as deep as one can wade to about as shallow as the diameter of the roller for the roller net, or to a skim of water for the beveled board net.

A net 4 feet wide suffices for small slow-

swimming fish such as seahorses and the darter, *Etheostoma fonticola*. An 8-foot-wide net is superior for general collecting, for it catches more species, larger specimens, and many more individuals of the faster-swimming species than does the smaller net.

A shallow bag, as used by Tampa Bay fishermen, is better for small slow-moving fish, since it keeps the trash and fish spread out and thus facilitates removal of the fish. A deep bag causes the trash and fish to form balls, which make isolation of small fish difficult. Only short pushes can be made with a shallow-bag net since the trash spreads out and quickly clogs the meshes. A deep bag permits long pushes because the trash is concentrated in the rear of the bag, thus leaving the anterior meshes open for straining water. For larger and faster-swimming fish a deep bag is better than a shallow bag.

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## A Study of Amphibian Movement in the Jackson Hole Wildlife Park

CHARLES C. CARPENTER

THE western spotted frog (*Rana p. pretiosa*) and the northwestern toad (*Bufo b. boreas*) are found commonly along small streams, backwaters of the larger streams, pot-holes, sloughs, and in damp areas of Jackson Hole in the Grand Teton National Park of Wyoming. During July and August of 1951, the opportunity was afforded me thru a grant-in-aid from the New York Zoological Society to make observations on the movements of these two species in the Jackson Hole Wildlife Park, near Moran, Wyoming.

For these observations, two small creeks were chosen. The first, designated as Willow Creek, was approximately 325 feet in length. Draining a wet meadow and emptying into the Snake River, this creek varied in width from 2 feet at the upper end to 5 feet at the mouth, and in depth from 3 inches to 2 feet. High banks with overhanging willows closely

bordered most of the creek and a few low banks of open grass and sedge were present. The bottom varied from gravel in the shallow portions, to mud in the deeper regions.

The second area, designated 3-Angle Pools, consisted of a part of a creek draining a very large, wet meadow. The stretch chosen was about 430 feet in length. The width varied from 5 to 20 feet, and the depth from 2 to 4 feet in the central part. The shore varied from steep, 3-foot banks with many small muddy notches cut back into them, to mud flats at water level. The higher banks were covered with grasses and willows; while sedges grew along the mud flats, which had scattered stumps and root tangles. A small beaver dam crossed the stream at the angle from east to south. The current normally was such that a frog or toad swam against it with difficulty; and, after a

TABLE I  
NUMBER AND PERCENTAGE OF INDIVIDUALS OF  
*Rana p. pretiosa* AND *Bufo b. boreas* MARKED AND  
RECAPTURED IN THE JACKSON HOLE WILDLIFE  
PARK, TETON NATIONAL PARK, WYOMING,  
DURING JULY AND AUGUST, 1951

	3-Angle Pools		Willow Creek		Total	
	<i>Rana</i>	<i>Bufo</i>	<i>Rana</i>	<i>Bufo</i>	<i>Rana</i>	<i>Bufo</i>
Total marked.....	24	47	34	12	58	59
Number of individuals recaptured.....	10	16	13	3	23	19
Percentage of individuals recaptured.....	42	34	38	25	40	32
Total of all captures and recaptures.....	39	73	52	18	91	91
Total number of all recaptures.....	15	26	18	6	33	32
Percentage of total of all recaptures..	38	36	35	33	36	35

rain, the water level rose and the current increased for a few hours.

Individuals were marked by clipping their toes (either one or combinations of two or three) off at their base with a fine scissors. Separate mark series were used for the two species. Each of the two areas was visited fourteen times at intervals of from 2 to 5 days. All individuals were released at the point of capture immediately after marking. Of the 19 individuals of *Bufo b. boreas* recaptured, 12 were retaken once, four twice, and one each, four and five times. Of the *Rana p. pretiosa*, 18 were retaken once, three twice, and one each, four and five times. (Table I).

Limited movement in the two amphibians is indicated in the following ways. The relatively high success in retaking marked individuals (*Rana*, 40 percent; *Bufo*, 32 percent) within the areas selected suggests that few individuals left the area and that there was a slow turnover in the local population.

By plotting recaptures on maps, the *minimum*

TABLE II  
RECAPTURE RECORDS FOR *Bufo b. boreas* IN THE JACKSON HOLE WILDLIFE PARK, WYOMING, SUMMER OF 1951

Toe mark	Sex*	Days elapsed between successive captures					Distance in feet between successive captures					Total elapsed days	Total distance (mini-mum, feet)	First-Last-Capture-Distance	Mini-mum feet moved per day	
		1-2	2-3	3-4	4-5	5-6	1-2	2-3	3-4	4-5	5-6					
(Willow Creek)																
AI	?	7	..	..	..	..	26	..	..	..	..	7	26	26	3.71	
BG	♀	8	..	..	..	..	112	..	..	..	..	8	112	112	14.00	
CJ	♂	2	4	3	12	..	13	155	60	100	..	21	328	14	15.62	
(3-Angle Pools)																
AB	J	4	..	..	..	..	0	..	..	..	..	4	0	0	0.00	
AC	♂	17	19	..	..	..	46	46	..	..	..	36	92	0	2.55	
AD	♂	8	..	..	..	..	46	..	..	..	..	8	46	46	5.75	
AE	♂	4	4	3	4	9	26	86	67	22	40	24	241	80	10.04	
AG	♀	17	..	..	..	..	140	..	..	..	..	17	140	140	8.23	
AK	♀	4	24	..	..	..	24	0	..	..	..	28	24	24	0.86	
AM	J	28	..	..	..	..	100	..	..	..	..	28	100	100	3.57	
AP	♂	7	..	..	..	..	5	..	..	..	..	7	5	5	0.71	
BD	♀	4	..	..	..	..	0	..	..	..	..	4	0	0	0.00	
BK	♀	7	2	15	..	..	26	68	52	..	..	24	146	48	6.08	
BN	♂	7	6	..	..	..	0	0	..	..	..	13	0	0	0.00	
CH	?	4	..	..	..	..	6	..	..	..	..	4	6	6	1.50	
DE	J	4	..	..	..	..	172	..	..	..	..	4	172	172	43.00	
GI	J	8	10	..	..	..	68	12	..	..	..	18	80	80	4.44	
HI	J	10	..	..	..	..	32	..	..	..	..	10	32	32	3.20	
HO	J	7	..	..	..	..	5	..	..	..	..	7	5	5	0.71	

\* J = juvenile.

TABLE III  
RECAPTURE RECORDS FOR *Rana p. pretiosa* IN THE JACKSON HOLE WILDLIFE  
PARK, WYOMING, SUMMER OF 1951

Toe mark	Sex*	Days elapsed between successive captures					Distance in feet between successive captures					Total elapsed days	Total distance (minimum, feet)	First-Last-Capture-Distance	Minimum feet moved per day	
		1-2	2-3	3-4	4-5	5-6	1-2	2-3	3-4	4-5	5-6					
(Willow Creek)																
AH	J	11	..	..	..	..	3	..	..	..	..	11	3	3	0.27	
AI	J	7	..	..	..	..	20	..	..	..	..	7	20	20	2.86	
AJ	J	11	..	..	..	..	22	..	..	..	..	11	22	22	2.00	
AO	♀	4	..	..	..	..	80	..	..	..	..	4	80	80	20.00	
AQ	J	4	..	..	..	..	13	..	..	..	..	4	13	13	3.25	
AR	J	4	6	15	4	6	21	8	30	8	4	35	71	29	2.03	
BC	J	4	..	..	..	..	76	..	..	..	..	4	76	76	19.00	
BN	J	2	..	..	..	..	34	..	..	..	..	2	34	34	17.00	
BO	J	34	..	..	..	..	65	..	..	..	..	34	65	65	1.91	
CD	J	25	..	..	..	..	66	..	..	..	..	25	66	66	2.64	
CK	J	6	6	..	..	..	17	18	..	..	..	12	35	2	2.92	
DF	J	6	..	..	..	..	22	..	..	..	..	6	22	22	3.67	
DI	♂	13	..	..	..	..	148	..	..	..	..	13	148	148	11.38	
(3-Angle Pools)																
AB	J	8	7	2	32	..	0	0	0	110	..	49	110	110	2.24	
AC	J	8	..	..	..	..	0	..	..	..	..	8	0	0	0.00	
AF	J	17	..	..	..	..	0	..	..	..	..	17	0	0	0.00	
AL	J	20	..	..	..	..	24	..	..	..	..	20	24	24	1.20	
BG	J	3	..	..	..	..	4	..	..	..	..	3	4	4	1.33	
BP	J	27	..	..	..	..	120	..	..	..	..	27	120	120	4.44	
CF	J	3	..	..	..	..	43	..	..	..	..	3	43	43	14.33	
CH	J	25	2	..	..	..	22	10	..	..	..	27	32	20	1.18	
CN	J	4	13	..	..	..	0	0	..	..	..	17	0	0	0.00	
DK	♀	7	..	..	..	..	26	..	..	..	..	7	26	26	3.71	

\* J = juvenile.

distances moved between successive captures (movement between these points was undoubtedly not in a straight line, but very irregular, and therefore much longer) can be determined for the lapsed period of time (Tables II and III). These data indicated that, although an individual toad or frog may have moved extensively within the area, it had traveled a relatively short distance from the point of original capture in the lapsed period of time. The range in "minimum" feet moved per day for *Bufo b. boreas* was 0 feet for 13 lapsed days to 43 feet for 4 lapsed days, and the daily average for all records was 6.52 minimum feet. For *Rana p. pretiosa*, the range was 0 feet for 17 lapsed days to 20 feet for 4 lapsed days, with an average of 5.0 minimum feet per day for all records.

When the movements of individuals captured

three or more times are plotted, the resulting patterns indicate that there is a tendency for individuals to return toward the point of original capture (Fig. 1). This is also clearly shown by the use of the determined first-last-capture-distance (distance between the original point of capture and the last point of capture) for those same individuals (Tables II and III, Fig. 1). This distance, in all patterns except one, is much less than that between the two most separated points of capture. Some individuals were recaptured at the same point two to four times, over more than a two-week period. (A large *Bufo b. boreas*, marked along the drain from an artesian well near my cabin, was captured on 8 different evenings over a period of 19 days within an area of 300 square feet.) One *Bufo* was retaken after 17 days, 46 feet from the point of original

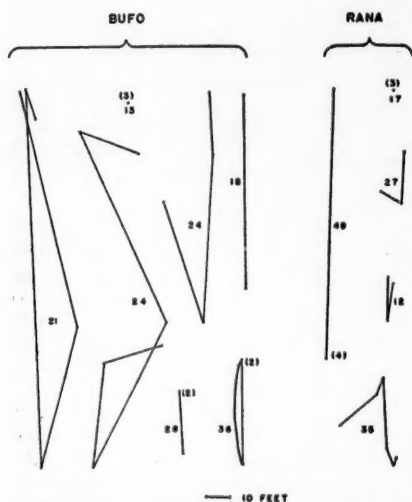


Fig. 1. Distributional pattern of capture records for *Bufo b. boreas* and *Rana p. pretiosa*. Each dot represents a point of capture. Numerals unparenthesized designate number of days between first and last capture. Parenthesized numerals designate the number of captures at that point.

capture; 19 days later it was retaken back at the point of original capture.

If these two species of amphibians did not have some form of limited activity range, one would expect the pattern of movement to be much more at random, that is, extending farther away from the points of original capture. The habitats surrounding these two study areas were favorable for the species

concerned and there appeared to be no barriers which would limit movement.

Since the current in the two small streams was swift during and after heavy rainfalls, toads and frogs caught in the torrent could be carried downstream for considerable distances before gaining a hold on the bank. This, I believe, may account for the fact that there was some extended movement downstream. The greatest turnover in population appeared to be after downpours, but this could have been due to migration which is a common occurrence during and immediately following rains.

No significant differences were found in the movements of individuals of different sizes or of the two sexes, and there were insufficient data to reveal whether or not differences between the two species existed.

Although the two species were found closely associated in both habitats, *Bufo* was much more abundant at 3-Angle Pools, while *Rana* was more numerous at Willow Creek (Table I). Since Willow Creek is the smaller and shallower stream with a greater abundance of bordering grassy areas, it seems that *Rana* would generally prefer this type of niche to the deeper and wider stream where the banks were generally steep and the grassy areas less accessible, and where much of the shore line was very muddy. *Bufo* was especially abundant among the root tangles along the banks of the 3-Angle Pools.

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## A New Species of *Gyrinophilus* (Plethodontidae) from Tennessee Caves

EDWARD McCRADY

**C**AVE salamanders are rare both in number of individuals and species. Excluding certain more or less transient and only slightly specialized forms found both in and out of caves, like several species of *Eurycea*, there are in the whole world only four known genera of what may be called true cave salamanders or troglodytic forms, that is to say, salamanders showing marked specialization for cave life,

and living, in the adult stage at any rate, nowhere but in caves. Furthermore, these four genera comprise only five, or possibly six, species so far described. They are: *Proteus anguinus* from the caves of the eastern Adriatic coastlands; *Proteus zoissi* (probably a subspecies of *anguinus*) from the same general region; *Typhlotriton spelaeus*, and *Typhlotriton nereus*, both from the caves of the Ozark Plateau;

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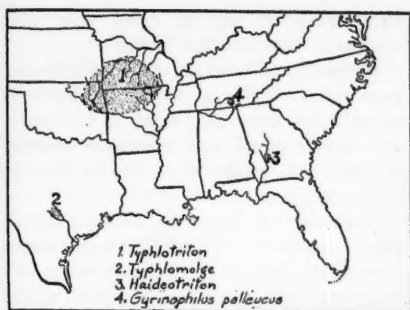


Fig. 1. Distribution of North American troglodytic salamanders, slightly modified from Bishop (1943).

*Typhlomolge rathbuni* from artesian wells and caves in Texas; and finally, *Haideotriton wallacei* from a 200-foot well at Albany, Georgia. Of this last genus only a single specimen has so far been seen. The purpose of this paper is to describe a new species of the genus *Gyrinophilus* from caves in the Cumberland Plateau near Sewanee, Tennessee (see Fig. 1).

Its discovery was actually made in 1944. At the meeting of the Tennessee Academy of Science held at Vanderbilt on December 1 of that year, I exhibited preserved specimens, showed motion pictures of living ones in color, and described the new species orally. The title of that talk on a short abstract appeared in the *Journal of the Tennessee Academy of Science*, Volume 20, 1945, page 325. Another reference appeared in the *New York Times* on October 5, 1947. I postponed publishing the full paper in the hope of clearing up the question of neoteny; but the pressure of other duties has prevented my obtaining conclusive evidence on that point, and since several people have become interested in the new species I have been persuaded not to delay publication any longer.

**ACKNOWLEDGEMENTS.**—In the discovery and collection of these salamanders all credit should be shared equally with Dr. Henry T. Kirby-Smith and Mr. Harvey Templeton, Jr., with whom nearly all of my cave exploring has been done. Mr. Clifford Pope of the Chicago Natural History Museum confirmed our impression that we had found an interesting form and gave advice and references to the

literature. The late Dr. Sherman C. Bishop of the University of Rochester supplied larval specimens of *Gyrinophilus porphyriticus*, *Eurycea bislineata*, *Typhlotriton spelaeus* and *Typhlotriton nereus* for comparison. Dr. Emmett Reid Dunn of Haverford College furnished larvae of *Pseudotriton ruber* for the same purpose. Large larvae and adults of *Gyrinophilus danielsi dunni* were obtained from Mr. J. C. Nichols of Andrews, North Carolina. Large adults of *Gyrinophilus porphyriticus* from Afton Cave, Green County, Tennessee, were received from the late Prof. Mike Wright of Tusculum College. Finally, Dr. Arnold B. Grobman, of the University of Florida, more than anyone else was responsible for prodding me into print. To all of the above I wish to express my very hearty thanks.

*Gyrinophilus pallescens*, sp. nov.

Fig. 2

**TYPE.**—Chicago Natural History Museum, a female, total length 146 mm.; from Sinking Cove Cave, Franklin County, Tennessee.

**RANGE.**—The type locality is Sinking Cove Cave (altitude 900 feet) in a hardwood climax forest at the north end of Sinking Cove, Franklin County, Tennessee, 5 miles west of Sherwood across Burned Stand Ridge, and 15 miles southwest of Sewanee. All of the specimens, upon which this description of *G. pallescens* is based, were taken from this one cave as a precaution in behalf of uniformity. But very similar specimens have also been found in four other limestone caves in Franklin County: Cave Cove Cave (altitude 1200 feet), 2 miles west of Sinking Cove Cave, the drainage from which, after a surface interval, passes into and through Sinking Cove Cave; Salt River Cave (altitude 900 feet), 5 miles south of Sinking Cove Cave and across a ridge, with almost certainly no underground or surface downstream connection with the latter; Lost Cove Cave, 7 miles northeast of Sinking Cove Cave across mountains and coves, but with drainage on the same side of the mountain range; and finally, Big Mouth Cave, 10 miles northeast of Sewanee, near Pelham, on the Elk River drainage. These five caves are all in the same type of hardwood forest and within 30 miles of each other; but the first four mentioned are part of a drainage which reaches



Fig. 2. *Gyrinophilus pallencus*, sp. nov., female, actual length 145 mm. ( $5\frac{7}{8}$  inches), Franklin County, Tennessee; drawn by the author from an enlarged 16-mm. motion picture frame, and the specimen.

the Tennessee River within 30 miles, whereas the stream from the fifth runs some 80 miles before reaching the same river. The salamanders from these caves differ among themselves in a degree roughly proportionate to the drainage differences of their caves. Those from Big Mouth Cave (the most remotely related in drainage) justify separate description. The others might be considered conspecific without much uncertainty; but to be on the safe side,

this description will be based only upon specimens from the type locality.

No specimens of larvae or adults have ever been found outside of caves, or outside of water in the caves. They occur on both sandy and rocky bottoms, and show some tendency to crawl into cracks or to burrow into the sand, when disturbed.

**DIAGNOSIS.**—A large ( $5\frac{1}{2}$  inches, average), pale, possibly neotenic species, with reduced eyes, normal legs, 16 costal grooves and 6 to 7 intercostal spaces between the toes of the appressed limbs; toes 4, 5, free; pterygoid teeth in single and exceptionally long series (11–13), never in patches; single premaxilla (bearing 20–28 teeth) with fontanelle, nasal spines not fused.

**DESCRIPTION OF THE SPECIES.**—Except for the gills and eyes, living specimens have a pale, flesh-pink appearance due almost wholly to the blood seen through the translucent tissues. The gills with their rich blood supply and thin covering have a correspondingly rich red color. The eyes are small and black. A very delicate tannish gray pigmentation is discernible on the dorsal and lateral surfaces of the body, but not on the ventral. In some specimens it is appreciably denser on the head, mid-dorsal line, and extensor surfaces of the legs. The pigment seems to be located in the lower layer of skin and shows best in specimens from which the outer layer has been removed. (It seems rather browner in formaldehyde specimens and grayer in alcohol.) Its distribution is smooth and interrupted only by the completely unpigmented larval spots (Dunn, 1926; 49). These spots are not visible in all specimens, and in any case, are confined to the dorsal and lateral series, the ventral series being eliminated by the general absence of pigment in this region.

**SIZE.**—The seven specimens described here, the first to be obtained from Sinking Cove Cave, range in total length from 155 mm. ( $6\frac{1}{8}$  in.) to 130 mm. ( $5\frac{1}{8}$  in.) with an average of 143 mm. ( $5\frac{7}{8}$  inches) which is probably in the right order of magnitude for average adult proportions. This is the largest American cave salamander so far discovered.

**EXTERNAL FEATURES.**—The general body shape is similar to that of larvae of other species of *Gyrinophilus*, but differs in having

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almost no pigment, very much reduced eyes, a slightly broader and more spade-like snout, and in attaining considerably greater size without losing its larval features.

The eyes in the largest specimen (155 mm.) are 1 mm. in diameter, 6 mm. apart, and 5 mm. from an imaginary transverse line tangent to the tip of the snout. They have no lids, and are attached to the integument, which is transparent over the pupil and translucent elsewhere. The large ratio of snout length to eye diameter (5:1) is not due to great length of snout, but to the unusual smallness of the eye. A 60-mm. (2½-inch) *Gyrinophilus porphyriticus porphyriticus* larva has an eye already as large as that of the largest *G. pallencus*, but its snout-eye ratio is only 2.6:1. The largest snout-eye ratio I have found in any *Gyrinophilus* larva of any other species is barely 3:1. Specimens of *pallencus* that have been raised in open daylight in aquaria for a year and a half show no change of relative eye size or of pigmentation, so these are probably valid taxonomic differences, not merely environmental effects.

No responses to light or shadow have yet been identified, but experiments conducted thus far are not convincing, as responses of well oculated forms are very uncertain.

The head is broadest just craniad of the base of the gills and tapers gently forward from there to a wide and bluntly rounded snout. A local swelling marking the masseter muscle at the corner of the jaws makes a slight interruption of this tapering line which is quite marked in some preserved specimens.

There is no naso-labial groove, and the external nares are extremely small. Typical larval labial folds are present.

There are three gills on each side, and in preserved specimens they reach back to the middle or beyond the base of the foreleg. In the living animal they are much larger and fluffier and tend to curl upward and forward over the head (Fig. 2). Confinement in aquaria also seems to result in some reduction of the gills. Under natural conditions in the cave some gill rami are well over a centimeter in length. Each ramus is supplied with 21 to 33 fimbriae in each of two rows on its caudal edge. The rami regenerate when lost individually, but if all are removed, the animal invariably dies before regeneration is accomplished. In one

TABLE I  
DIMENSIONS AND RATIOS IN THE TYPE SERIES OF  
*Gyrinophilus pallencus*

Total length (mm.)	Length of parts (mm.)			Ratio of parts Head:Body:Tail
	Head	Body	Tail	
155	18	75	62	1:4.17:3.4
154	17	70	67	1:4.12:3.9
146	18	64	64	1:3.56:3.56
143	18	70	55	1:3.9:3.6
139	17	66	56	1:3.8:3.2
135	17	60	50	1:3.5:2.9
130	16	62	50	1:3.9:3.1

case which I have seen, the first ramus was bifurcated.

The head was measured from the snout to the middle of the gular fold, the trunk from the middle of the gular fold to the posterior angle of the vent, and the tail from the posterior angle of the vent to its tip (Table I).

The number of costal grooves is 16, counting one each in axilla and groin. The number of intercostal folds between the toes of the appressed limbs is 6 to 7½. With respect to these two features *G. pallencus* resembles *Typhlotriton spelaeus* in the first and not in the second; and resembles *T. nereus* in the second and not in the first. Other species of the genus *Gyrinophilus* tend to run to a larger number of costal grooves, 18 being the common count in both larvae and adults. The larvae of *Pseudotriton ruber ruber* have the same number of costal grooves, and intercostal folds between appressed limbs, as *G. pallencus*, but differ markedly in head shape, as will be discussed below in connection with the premaxillary bones.

There are four toes on the forefoot and five on the hindfoot. Those of the forefoot are 3, (4, 2), 1 in order of length; those on the hindfoot (3, 4), 2, 5, 1. (The numbers in parentheses indicate toes which vary from equality to reversed order in length.) There is no webbing between the toes.

The tail is fairly short (never longer than the trunk, though sometimes equal to it), averaging 3.3 times the head length, and quite thick in adults. It is generally slightly thicker near its base than the pelvic region of the trunk. The dorsal fin never extends onto the trunk. It

arises above the pelvis as a very thick low ridge, more than  $\frac{1}{2}$  as wide horizontally as the tail. From  $\frac{1}{8}$  to  $\frac{1}{2}$  its way back the fin develops a thinner and more translucent crest which expands rather abruptly in vertical height, and in the caudal third completely displaces the thicker base first mentioned. Its point of greatest height is about its middle. The maximal dimension so far recorded at this point (including both dorsal and ventral fins) is 17 mm. The fin passes around the tip of the tail with a contour which varies from a semi-circle of 15 mm. diameter to a blunt angle of some 60°. There is never a very acutely pointed tip except in cases of injury. The ventral fin is confined to the caudal half of the tail except for the low, thick translucent base which can be recognized nearly as far cranial as the vent.

The lips of the cloaca are smooth. Usually in males and occasionally in females there is a wrinkle or fold in the cranial angle of the vent.

**MISCELLANEOUS INTERNAL DETAILS.**—The teeth and tongue are larval in character and much resemble those of other species of *Gyrinophilus*. The premaxillary teeth are 20 to 28 in total number. This may be described as 10–14 on each side, since only lateral counts are given for the vomerine and pterygoid series, but it must be remembered that the premaxillary bone is single in *G. pallencus* and there is no interruption in this line. The vomerine teeth are 14–17; pterygoid 10–13. In all of these sets the teeth are in single series. In this last respect the pterygoid teeth differ from those of *Typhlotriton speleus* and *T. nereus* where they occur in patches. *G. pallencus* differs from larvae of other species of *Gyrinophilus*, and from larval *Pseudotriton* and *Eurycea*, principally in the greater number of premaxillary and pterygoid teeth. The typical larval counts in these three genera are: *Gyrinophilus*—P8, V13, PT7; *Pseudotriton*—P4, V10, PT2; *Eurycea*—P5, V11, PT5. The closest resemblance in tooth formula is thus found in other species of *Gyrinophilus*, but even there the difference in both the premaxillary and pterygoid series is considerable. The large number of premaxillary teeth in *G. pallencus* is correlated with the greater length of the premaxillary bone, which affects the shape of the head. In fact, this is the most

striking difference between *G. pallencus* and *Pseudotriton*, causing a broad spade-like snout in the former, and a much narrower one in the latter.

One other comment is needed about the premaxillary bone. The fact that it is single in the adults of all American cave salamanders where its condition is known (i.e., in *Typhlotriton*, *Typhlomolge*) and in *Pseudotriton* and *Eurycea*, whereas it is double in the adult *Gyrinophilus*, might be interpreted as indicating either *Pseudotriton* or *Eurycea* as a more likely source of the cave forms than *Gyrinophilus*. This was my own conclusion until I examined a larval *Gyrinophilus* and found the premaxillary single there also. I dissected, cleared, and stained several more of two different species (*G. porphyriticus porphyriticus* and *G. danielsi dunni*), and found it to be true in all. This throws a new light on the question of relationships among these genera. Dunn, who believes that *Pseudotriton* is the source stock of all the cave salamanders of North America, has emphasized that the neotenic or branchiated forms must be compared not with the adults but with the larvae of normally metamorphosing genera. He is certainly right in this; but then, one must reconsider *Gyrinophilus* as a source stock, and it is quite possible that there has been more than one source. The most obvious way to pursue the problem of relationships is to try to induce the new species to metamorphose. I have started an experiment in this direction using thyroid extract, with initial signs of success, but ending with the death of the animal. The fact that definite response to the thyroid administration in the form of increased pigmentation, reduction of gills and tail fins, and considerable sloughing of skin was manifested, gives hope that I shall succeed with this experiment later. Induction of metamorphosis in addition to extending our knowledge of the premaxillary condition would also permit comparisons of the prefrontals or lacrymals. These are not present in the larvae of any forms or in neotenic adults, but in the adult *Pseudotriton* they border the nares, whereas in the adults of *Gyrinophilus* and *Typhlotriton* (the only troglodytic salamander which metamorphoses) they do not.

The internal nares open just laterad of the posterior end of the vomerine series of teeth.

The tongue, as in all larvae and neotenic forms, arises from the ceratohyal cartilages to which it is attached posteriorly. There is no frenulum. There is also no lingual cartilage. This last structure, which is so conspicuous in adult *Gyrinophilus*, does not arise until metamorphosis, so its absence in *palleucus* can not be taken as significant.

The hyobranchial apparatus consists of 2 basibranchials, 1 pair of ceratohyals, 2 pairs of ceratobranchials, and 3 pairs of epibranchials. The second basibranchial and the first pair of ceratobranchials are fused into a branchial plate (Smith, 1920). There is no separate os thyroideum, though its anlage is clearly recognizable in the caudal end of the branchial plate.

In the skull, it has already been mentioned that there is only one premaxillary bone. Its nasal spines are not fused, but make contact and enclose a fontanelle. The nasal capsules are long and tubular, and are membranous, not cartilaginous. Starting caudally at the inner canthus of the eye they run forward and then diverge laterad, instead of continuing straight forward or converging. This is probably due to the exceptional width of the premaxilla. There are no nasal bones, no septomaxillaries, no prefrontals, no maxillaries. The occipital condyles are sessile. The atlas is normal. There is no ypsiloid cartilage.

According to Piatt (1940) the genioglossus muscle is completely missing in all the genera of what he calls the *Stereochilus* and *Gyrinophilus* groups (i.e., in *Stereochilus*, *Typhlotriton*, *Gyrinophilus*, *Pseudotriton*, *Eurycea*, and *Manculus*). It is present in *pelleucus*, but this may not be significant. Piatt (*op. cit.*: 224) listed *Typhlomolge* in the *Stereochilus* group but explained that he had omitted it from all subsequent discussion because it could not profitably be compared with the adults of the other genera. Unfortunately also, Miss Emerson (1950) omitted this particular muscle from her account of the myology of *Typhlomolge*, so we do not yet know whether *Typhlomolge* has a genioglossus muscle or not; and only *Typhlomolge* could be profitably compared in the adult condition with *palleucus*. I hope to make larval comparisons later.

There are two well developed structures which on evidence from other salamanders

(though I have not yet seen them in microscopic sections) I take to be thyroid glands, situated on the rectus abdominis muscles between the ventral end of the branchiohyoid externalis and the caudal end of the geniohyoid muscle, one on each side. Just above the gills between the depressor mandibularis and the levatores branchiarum there is a conspicuous glandular structure like that which Miss Emerson (1905) described in *Typhlomolge* as a thymus gland. As she has seen it in sections her identification is presumably right, though the position seems more suggestive of parathyroids. It is doubtless also the same structure which Bishop (1944) noticed in *Typhlotriton nereus* and *Eurycea neotenes*, but found lacking in *Typhlotriton speleus*, *Eurycea multiplicata*, and *E. nana*. I shall study it in sections later.

DISCUSSION.—That this is not the larva or adult of any known species is abundantly evident. Whether the new type has thus far been seen only in the larval state, or whether these specimens are neotenic adults, is not quite so easy to determine. I have not yet seen ripe eggs. The facts that, counting those from other caves, 31 specimens of the new species have been captured, ranging in length from 53 mm. (2½ inches) to 155 mm. (6½ inches), and all showing well developed gills and tail fins; that careful searches have been made under rocks and in crevices along the banks of the streams and the walls of the caves without ever finding any metamorphosed individuals; that specimens have been kept alive in aquaria for a year and a half, eating well and showing good health without any tendency to metamorphose; and that the largest of these are considerably larger than the maximum size recorded for the larvae of any of the related species; all lead me to feel that the presumptive evidence for the new species being neotenic is strong, though not conclusive.

Oddly enough, aside from ripe sexual products, which can be expected only in the breeding season (whenever that is), there are no simple definitive criteria for adulthood. These specimens certainly have for the most part the features of a plethodontid larva of what Wilder (1925) calls the incipient pre-metamorphic stage—to wit, absence of nasolabial groove, presence of labial folds, presence of gills and tail fins, the arrangement of the

teeth and the form of the tongue, absence of the lingual cartilage and os thyroideum, absence of nasal bones, septomaxillaries, maxillaries, and prefrontals. All of these features could be interpreted as larval, but it must be remembered that every one of them is equally characteristic of the adult *Typhlomolge*. The final solution of that question therefore must await the discovery of the breeding season and the finding of ripe eggs in the ovaries.

According to Wilder (1925: 131-2) in *Eurycea bislineata* Waterman has shown that there is no regular correlation between development of the gonads and metamorphosis. There is a considerable range of variation in this respect from individual to individual. The only two features of the urinogenital system which she mentions as distinctive of the adult condition are: 1) the presence of the Müllerian ducts; 2) the replacement of the pronephros by the mesonephros. In both of these respects all of my large specimens are adults. And it should also be mentioned that in a few females I have seen eggs as large as  $\frac{1}{2}$  mm. in diameter.

In connection with the raising of these salamanders in ordinary laboratory aquaria, it should be pointed out that both *Typhlotriton* and *Proteus* develop extensive pigmentation on exposure to light (Noble, 1931: 149). *Typhlotriton* develops functional eyes under these conditions (Noble and Pope, 1928) and so does *Proteus* if exposed to red and white light alternately, according to Kammerer (1912). The effect on *Typhlomolge* and *Haideotriton* is not known. *Gyrinophilus pallescens* shows no response in either pigment or eyes, so in this respect is more specialized than *Typhlotriton* and *Proteus*.

Aside from the morphological data which it would yield, the possibility of artificial induction of metamorphosis is interesting from a physiological point of view. Some neotenic

forms have a functional thyroid which will induce metamorphosis in other amphibia and in themselves, if artificially administered, but from which in the natural condition the hormone is apparently unable to escape into the blood stream (axolotl); others have a thyroid which is either non-functional or to the influence of which they are immune, as they can not be stimulated to metamorphose by any means known at present (*Proteus*, *Necturus*); *Typhlomolge* is said to have no thyroid at all, but it is not known whether it could respond to injected thyroxine or iodine, as the experiment has not been tried. So far no neotenic form has been induced to metamorphose into an unknown species of adult, though this possibility should be borne in mind. All of these considerations lend interest to the experimental attempt to induce metamorphosis in the new species which I hope to carry out in the future.

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# The Development of Labial Teeth of Salientian Larvae in Relation to Temperature

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THE seemingly endless variations that one normally encounters in each of the different kinds of mouth parts of salientian larvae are well known (Wright and Wright, 1949; Bragg 1950). To study simultaneously all the variations in each of the labial mouth parts is, at the present time, an almost impossible task. For this reason, one aspect, the rows of labial teeth and their possible variations due to environmental developmental temperatures, was chosen for rather intensive study.

## MATERIALS AND METHODS

One clutch of *Rana berlandieri* eggs was obtained from the State Game Preserve, McCurtain County, Oklahoma, on March 25, 1951.

On June 13, 1951, recently hatched larvae of *Bufo cognatus* were collected from a pool at Norman, Oklahoma. The larvae were so young when found that they were extremely feeble in their movements; it is very doubtful that the animals had traveled even a moderate distance from the place of hatching.

Since both forms, *Rana berlandieri* and *Bufo cognatus*, generally have five rows of labial teeth, a numbering system suitable to this study was devised. Row No. 1 is the most dorsal row on the upper lip; row No. 2 is found immediately below row No. 1. On the lower lip, row No. 3 is the most dorsal, followed ventrally by rows No. 4 and No. 5, the latter of which is the most ventral. Pigmentation features of the mandibles had striking variations and these were examined in addition to the labial teeth.

The eggs of *R. berlandieri* and the tadpoles of *B. cognatus* were transferred to tanks, in the laboratory. The environmental conditions of water volume, light, and food were kept virtually identical within the two series of tanks. Water temperatures were controlled by thermostatic regulators.

**PROCEDURE WITH *Rana berlandieri*.**—Many species of *Rana* have clutches which contain thousands of eggs, fertilized and unfertilized. Since eggs toward the middle of the mass may

not receive a sufficient supply of oxygen necessary for development, the clutch of *R. berlandieri* eggs was dismembered into groups of from one to ten eggs. These small groups of eggs were placed in a water-filled basin and stirred thoroughly. The eggs were then drawn out at random from the basin and placed into tanks. In this way "outer" and "inner" eggs had proportionately equal chance of being chosen for the tanks. The eggs were found to be in the early neural plate stage of development at the time of placement in the tanks.

One hundred and fifty eggs of *Rana berlandieri* were placed in each of five tanks on March 26, 1951. One of the five aquaria was designated as a control. The temperature of this tank was deliberately allowed to vary with room temperature. Each of the other aquaria was maintained at a different temperature.

**PROCEDURE WITH *Bufo cognatus*.**—Four aquaria, each with 15 of the recently hatched *Bufo cognatus*, were placed in experimental operation on June 13, 1951. As in the other series, one of the aquaria was designated as a control. The temperature of this tank was deliberately allowed to vary with room temperature. As with *Rana berlandieri*, each of the other aquaria was maintained at a different temperature.

**TERMINOLOGY.**—Three terms are used extensively throughout the tables. "Absent," as used for the rows of labial teeth, means that they are not present and the ridges on which the teeth normally appear are also not present. For the mandibles, the designation "absent" has a slightly different meaning. Nichols (1937), in discussing mandibles, wrote "The upper beak appears (becomes heavily pigmented) . . ." Hence, it seems that the tadpole's mandibles can be likened to those of the turtle in which a horny beak is a sort of covering for the parts of the jaw. Accordingly, in this study the term "absent," insofar as mandibles are concerned, means the absence of pigmentation. "Poorly developed," in respect to the oral ridge, means one that has not more

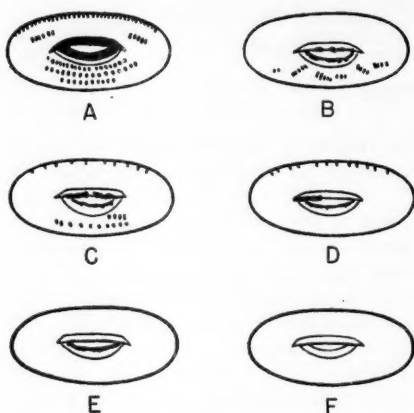


Fig. 1. Diagrammatic representation of composite mouth parts of larvae of *Bufo cognatus* and *Rana berlandieri* at the end of the experiments.

A, teeth and mandibles well developed; B, lower teeth irregular, upper teeth absent, mandibles poorly developed; C, teeth poorly developed, mandibles not developed in center; D, lower teeth absent, upper teeth poorly developed, mandibles poorly developed; E, teeth absent, mandibles poorly developed; F, teeth absent, mandibles absent.

than half the normal complement of teeth but does have three or more. "Poorly developed," in respect to the mandible, designates the degree of pigmentation. "Well developed" applies to the normal condition found in both ridges and rows of labial teeth and, in the mandibles, to the normal degree of pigmentation. "Well developed," as used through this work, is synonymous with the typical condition. Whenever the terms "absent," "poorly developed," or "well developed" do not describe the prevailing conditions, a fuller description is given (Tables I and III). Diagrammatic representations of the above definitions were also constructed (Fig. 1).

#### EXPERIMENTS

*Rana berlandieri*.—Approximately 20 percent of the embryos, regardless of the temperature of the medium into which they had been placed, died before hatching. For the first 6 weeks, spot counts every few days revealed that the number of animals in the temperature-controlled tanks remained relatively equal. At the end of 6 weeks, the tank kept at 33.5°C. contained many dead animals. Generally, the

mouth parts of these dead specimens were missing. This mutilation was probably the result of cannibalism. Because of the increased death rate in the tank kept at 33.5°C., the experiments were terminated and the tadpoles preserved on June 7, 1951.

The temperatures in the four tanks in which temperatures were controlled were 17.5±.5°C., 20±.5°C., 25±.6°C., and 33.5±.6°C.

The specimens kept in a tank at room temperature were found dead on the second day of experimentation. The cause of death is unknown.

Abnormalities of labial teeth and mandibles developed more frequently at the higher temperatures. The best-developed teeth and mandibles were exhibited by the animals kept at 17.5°C.; the poorest, by those kept at 33.5°C. (Table I).

The various rows of labial teeth and the mandibles did not develop equally well under the different developmental temperatures. Row No. 1 was the best developed in the entire series of both *Rana berlandieri* and *Bufo cognatus*. The succeeding rows, in order of best development, were numbers 3, 4–5, and 2. Thus, the rows of teeth exhibited different degrees of "developmental hardness."

Many different kinds of labial formulae resulted from these temperature experiments with *Rana berlandieri*. Each labial formula was arbitrarily placed into one of two categories, typical or atypical. The labial formulae of 2/3 and 1/3 were considered as typical, following the example of Bragg (1950). The labial formulae of the atypical animals were less than 1/3 and occasionally reached 0/0, a formula found in six tadpoles kept at 33.5°C. Increases in developmental temperature are associated with increases in atypical labial patterns (Table II).

The mandibles were generally well developed regardless of the temperatures in which they had taken form. The exception to this was the condition of the upper mandibles developed at 33.5±.6°C.

*Bufo cognatus*.—Tadpole length and general development are correlated to a fair degree. Sixteen millimeters was chosen as the over-all length at which to kill and preserve the animals. At this length, the width of the mouth region is less than 1 mm.

TABLE I

EFFECT OF TEMPERATURE ON THE DEVELOPMENT OF LABIAL TEETH AND MANDIBLES IN TADPOLES OF *Rana berlandieri*

Temperature of medium (°C):		17.5±.5	20.0±.5	25.0±.6	33.5±.6
Number of specimens:		109	114	116	39
Mouth part	Condition	Percentages			
Teeth, row 1	Well developed	100	100	96	18
	Poorly developed	...	...	4	31
	Absent	...	...	...	51
Teeth, row 2	Well developed	100	94	90	3
	Poorly developed	...	6	1	..
	Absent	...	...	9	97
Upper mandible pigmentation	Well developed	100	100	100	46
	Poorly developed	...	...	...	20
	Absent	...	...	...	3
	Not developed in center	...	...	...	31
Lower mandible pigmentation	Well developed	100	99	100	94
	Poorly developed	...	1	...	3
	Absent	...	...	...	3
Teeth, row 3	Well developed	98	100	97	3
	Poorly developed	...	...	3	13
	Absent	...	...	...	74
	Irregular row	2	...	...	10
Teeth, row 4	Well developed	98	99	97	3
	Poorly developed	...	1	3	20
	Absent	...	...	...	54
	Irregular row	2	...	...	10
	Ridge present, no teeth	...	...	...	13
Teeth, row 5	Well developed	98	99	97	3
	Poorly developed	...	1	3	26
	Absent	...	...	...	46
	Irregular row	2	...	...	10
	Ridge present, no teeth	...	...	...	15

During the experiments for this species, the mean temperatures in three tanks were  $16\pm.4^{\circ}\text{C}$ .,  $29\pm.5^{\circ}\text{C}$ ., and  $32.5\pm.5^{\circ}\text{C}$ . The mean of the tank that varied with room temperature was  $28.5\pm 1.7^{\circ}\text{C}$ .

While the number of *Bufo cognatus* used in the experiments was less than that in the *Rana berlandieri* series, the results were about the same. Abnormalities generally developed more frequently at higher temperatures (Table III). The animals kept at  $16.0^{\circ}\text{C}$ . contained the most perfectly formed labial

TABLE II

PERCENTAGE DISTRIBUTION OF LABIAL FORMULAE OF TADPOLES OF *Rana berlandieri* REARED IN FOUR DIFFERENT TEMPERATURE ENVIRONMENTS

Developmental temperatures, °C.	Number of specimens	Typical labial formulae		Atypical labial formulae
		2/3	1/3	
17.5±.5	109	96	2	2
20.0±.5	114	93	5	2
25.0±.6	116	88	5	7
33.5±.6	39	3	0	97

TABLE III  
EFFECT OF TEMPERATURE ON THE DEVELOPMENT OF LABIAL TEETH AND MANDIBLES IN  
TADPOLES OF *Bufo cognatus*

Temperature of medium (°C):		Controlled			Uncontrolled 28.5±1.7
		16.0±.4	29.0±.5	32.5±.5	
Number of specimens:		15	15	15	15
Mouth part	Condition	Percentages			
Teeth, row 1	Well developed	100	100	100	100
Teeth, row 2	Well developed	100	67	87	87
	Absent	...	33	13	13
Upper mandible pigmentation	Well developed	100	100	100	100
Lower mandible pigmentation	Well developed	100	100	100	100
Teeth, row 3	Well developed	100	87	87	100
	Poorly developed	...	...	13	...
	Absent	...	13	...	...
Teeth, row 4	Well developed	100	87	73	100
	Poorly developed	...	13	27	...
Teeth, row 5	Well developed	100	87	67	100
	Poorly developed	...	13	13	...
	Absent	...	...	20	...

teeth and most heavily pigmented mandibles of any group in either species.

The "developmental hardness" order of the rows of teeth was virtually identical with that existing in the *Rana* series—rows 1, 3, 4, 5, and 2. The mandibles were exceptionally well developed in all the animals of this series.

#### DISCUSSION

In the experiments the labial formulae, or total number of rows of labial teeth, were greater at the lower developmental temperatures. Given similar genetic composition (species or subspecies), it does not seem unreasonable to expect that tadpoles from cooler waters or those from more northern regions would have higher labial formulae than those taken from warmer waters or from more southern areas. The effects of extremely low temperatures upon developing mouth parts has not been ascertained. Accordingly, the negative correlation between mouth part development and temperature may have a limited value.

In *Rana pipiens*, Nichols (1937) found that the order of appearance of the rows of teeth in ontogeny is No. 1 first, generally followed by Nos. 3, 4 and 5, respectively. Row No. 2 usually appeared last but its order in the sequence was somewhat variable; however, it never appeared before No. 1 or No. 3. The order of appearance of the rows in the ontogeny of *Bufo w. fowleri* is like that of *Rana pipiens* (Nichols, *op. cit.*). If the order of row appearance is the same in *B. cognatus* and *R. berlandieri* as it is in *R. pipiens* and *B. w. fowleri* (and it probably is), then there is a relationship between that order and "developmental hardness." Thus row No. 1, which probably develops first, has the highest percentage of "developmental hardness" whereas No. 2, which is apt to develop last, has the lowest. This condition existed in both species of the experimental animals.

Of all the rows, No. 2 is most affected by temperature. In *Rana berlandieri* reared at 20°C., all rows of teeth except No. 2 were excellently developed. At 25°C., No. 2 was

absent in nine percent of the tadpoles; all other rows were present. (In its natural environment a *Rana* tadpole is more apt to lack row No. 2 than any other.)

The mouth parts of *Rana berlandieri* were affected by temperature even though the embryos were already in the neural plate stage of development when the experiments were begun. Although mouth parts had not yet made their appearance, the individuals of *Bufo cognatus* were in the larval stage at the commencement of the experiments. Nevertheless, despite this comparatively advanced stage, the development of mouth parts was still affected by temperature. Hence, it appears that the labial rows and mandibles are affected by environmental temperatures at any time before the actual development of these parts takes place.

The results of the experiments emphasize the need for much caution when utilizing labial teeth for taxonomic purposes.

#### SUMMARY AND ACKNOWLEDGMENTS

1. More abnormalities were present in the labial teeth of tadpoles of *Rana berlandieri* and *Bufo cognatus* reared at high temperatures than in those reared at low.

2. In both species the rows of labial teeth did not develop equally well under the different

developmental temperatures but exhibited different degrees of "developmental hardness."

3. The order of appearance of labial teeth in the ontogeny of either species is very probably correlated with a descending order of "developmental hardness" of the various teeth rows.

4. In both species the mandible pigmentation was generally well developed regardless of the developmental temperatures in which they had taken form.

The author wishes to express his gratitude to Dr. Arthur N. Bragg, University of Oklahoma, under whose guidance this topic was investigated. Sincere thanks are also given to Dr. S. Charles Kendeigh, University of Illinois, for his critical suggestions regarding the manuscript.

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## The Progress of Ossification in the Skull of the Cricketfrog *Pseudacris nigrita triseriata*

PAUL S. STOKELY AND JAMES C. LIST

THE need for morphological studies dealing with the larval stages of the Amphibia was pointed out by Orton (1946). Much of the literature relating to the subject of this present report, the ossification of the skull during the larval period of an anuran, is included in the review of de Beer (1937). Probably the most important is the paper of Erdmann (1933) reporting his observations on *Triton* and *Rana*. More recently Lynn (1942) described ossification in *Eleutherodactylus nubicola*, an anuran which has no tadpole stage.

The description given here is the result of

detailed observations of 23 specimens of the three-lined cricketfrog, *Pseudacris nigrita triseriata*. This particular species was chosen because of the availability of its eggs in large numbers, its relatively short larval period, and its small size, all being factors which made collecting eggs and rearing the larvae in the laboratory more convenient.

The specimens used comprise a series covering three weeks of larval growth beginning with the time of emergence of the forelimbs or "stage XX" of Taylor and Kollross (1946). Expressions such as "at 5 days" or "at 3 weeks"

indicate that number of days or weeks after stage XX had been reached. There were two specimens representing stage XX, four at 2 days, five at 5 days, one at 1 week, one at 10 days, one at 12 days, two at 2 weeks, two at 3 weeks, and five adults.

The specimens were cleared in KOH and the bones and calcified cartilages stained with alizarin sulfonate of sodium. A brief review of this technique is found in Cumley, Crow and Griffen, (1939). Each specimen was then imbedded in "Bio-Plastic," a polyester type thermosetting resin obtained from Ward's Natural Science Establishment, Rochester, N. Y. The plastic block makes handling of the specimens very simple and does not interfere appreciably with observation if the line of sight is perpendicular to the block's surface.

Drawings of the specimens were made by one of the authors, J. C. List, by tracing the images projected by a "Rayoscope" (Cardevaant Laboratories, Edwardsburg, Mich.) which usually furnished at least an outline of the structures. Details observed under a binocular dissecting microscope were filled in freehand. Only ossified or calcified structures were recorded.

Very few of the bones of the head have begun to ossify at stage XX. The most extensively ossified are those at the extremities, the premaxillae and the exoccipitals. The frontoparietals are indicated by two narrow bars and the calcification of the nasal cartilage forms two short curved structures (Fig. 1).

The premaxillae at stage XX have a form very much like those in the adult. They appear to be truly osseous, no calcified cartilage is apparent (Fig. 1). At this early stage they are oriented at an angle of about 45° to the horizontal. The chief changes that occur in the premaxillae during the 3-week period observed are (1) a general increase in size (most of it in the first week); (2) a relative lengthening of the basal portion; (3) a gradual assumption of a more vertical position; and (4) the appearance of teeth at about 5 days (Fig. 2).

An exoccipital at stage XX is an irregularly shaped bone with an elongate, slightly concave surface directed antero-laterad. A medio-posterior projection forms the occipital condyle. A ventral projection curves mediad a short distance (Fig. 1).

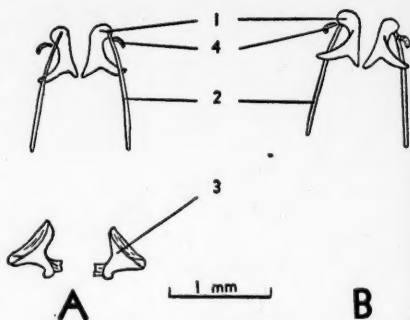


Fig. 1. Skull at stage XX. A, dorsal view; B, ventral view (exoccipitals obscured). Calcified cartilages are stippled in this and the following figures.

1, premaxilla; 2, frontoparietal; 3, exoccipital; 4, nasal cartilage.

By the end of two weeks each exoccipital has a short slender dorsal ossification projecting mediad and slightly forward. Later, the meeting, fusion and expansion of these two projections will form the roof of the foramen magnum.

At 3 weeks the dorsal process from the exoccipitals almost meet in the midline and the ventral processes have extended slightly farther mediad. Postero-laterally on each bone is a rather wide extension, the beginning of the dorsal and posterior walls of the auditory capsule. There is a slight calcification of cartilage at the surface of the occipital condyles. The remainder of the exoccipitals seems to be true bone (Fig. 3).

In the adult the two exoccipitals are extensive bones forming much of the posterior and dorsal walls of the auditory capsules. They surround the foramen magnum except at the midline of the roof and floor of the skull where small areas of calcified cartilage complete the ring. The articular surfaces of the occipital condyles are thinly covered with calcified cartilage (Figs. 4 and 5).

The frontoparietals at stage XX are merely two thin strands of ossification about 1.4 mm. in length, slightly curved laterad, and converging somewhat anteriorly. By 5 days they have reached a length of about 2.0 mm. but have changed little otherwise (Figs. 1 and 2). At 3 weeks they are essentially unchanged in appearance or size.

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Fig. 2. Skull at stage XX. A, dorsal view; B, ventral view (exoccipitals obscured). Calcified cartilages are stippled in this and the following figures. 1, premaxilla; 2, frontoparietal; 3, exoccipital; 4, nasal cartilage; 5, squamosal; 6, parietal; 7, frontal; 8, sphenoid.

Each adult frontoparietal is a slender, flattened bone about 3.2 mm. in length, joined to the exoccipital posterior to it by an area of calcified cartilage. The two frontoparietals extend forward essentially parallel to each other as far as the posterior-most dorsal portions of the sphenethmoid, which they slightly overlap (Fig. 4).

A pair of calcified nasal cartilages appear at stage XX. They are in the form of small curved bars and are located just posterior and lateral to the tips of the anterior processes of the premaxillae (Fig. 1).

One week later they have increased in length and have also become more sharply curved, forming a nearly complete, small circle with a diameter of about 0.2 mm.

In the adult they are found in the same location with respect to the premaxillae as they were at stage XX. They now constitute a complete circle (diameter 0.4 mm. or more) lying in a generally horizontal plane with the inner tip turned dorsad. Also in the nasal region of the adult may be found other small irregular patches of slightly calcified cartilage (Figs. 4 and 5).

The first ossified traces of the nasal bones appear between 3 and 5 days after stage XX. At 5 days they are merely two slender bars of ossification about 1.0 mm. in length. From near the midline at the tip of the snout each curves postero-laterad. The pair lies dorsal both to the calcified bars of the nasal cartilages and to the tips of the premaxillary processes (Fig. 2).

From this point through 3 weeks these bars of ossification shorten from the anterior end, that region apparently being decalcified. At 3 weeks they are only about 0.6 mm. long, but they have widened considerably in the central portion (Fig. 3).

In the adult the nasals are roughly triangular, about 2.4 mm. in length, rounded anteriorly, and sharply pointed posteriorly (Figs. 4 and 5).

Ossification in the pair of maxillae first appears between 3 and 5 days after stage XX. At 5 days the maxilla is a well ossified but slender bone about 1.5 mm. in length and slightly curved (Fig. 2). It progressively thickens and lengthens slightly through 3 weeks. Teeth begin to appear along its anterior one-third at about 10 days. This anterior one-third becomes noticeably thicker than the rest of the bone at 3 weeks. At this time the posterior end of the maxilla is still very slender and there is a short curve laterad just before it meets the quadratojugal (Fig. 3).

Each adult maxilla is about 6 mm. in length, much more slender posteriorly than anteriorly. About 1 mm. of its posterior end is fused to the quadratojugal. Anteriorly it meets a premaxilla but is not fused with it (Figs. 4 and 5).

The paired vomers first appear between 3 and 5 days after stage XX. At 5 days each bone is a small ossified patch approximately 0.1 mm. in diameter, sometimes with one or two teeth. The ossifications are in approximately the same location as the groups of vomerine teeth in the adult, in the anterior part of the roof of the mouth near the midline (Fig. 2).

There is practically no change in these two ossifications from 5 days through 3 weeks. However, at 2 weeks two other ossifications appear, lateral, slightly anterior, and a little ventral to the first pair. They are rather flat, slightly curved formations about 0.2 mm. long. The pointed ends of the curves are directed laterad.

At 3 weeks these second ossification centers of the vomers are somewhat larger, and the anterior end may be slightly expanded and less pointed (Fig. 3). These curved formations apparently continue to increase in extent, become continuous with the ossifications that bear the teeth and extend themselves farther anteriorad. The posterior ends of these second formations probably form the postero-lateral

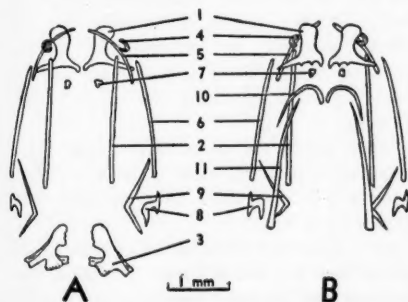


Fig. 2. Skull at 5 days after stage XX. A, dorsal view; B, ventral view (exoccipitals obscured). 1, premaxilla; 2, frontoparietal; 3, exoccipital; 4, nasal cartilage; 5, nasal; 6, maxilla; 7, vomer; 8, squamosal; 9, pterygoid; 10, dentary; 11, angulosplenial.

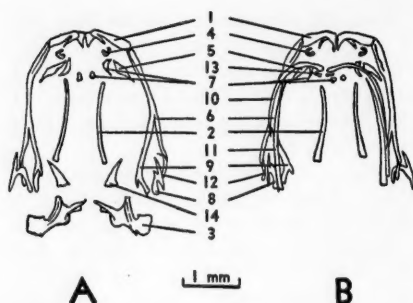


Fig. 3. Skull at 3 weeks after stage XX. A, dorsal view; B, ventral view (exoccipitals and prootics obscured). 1, premaxilla; 2, frontoparietal; 3, exoccipital; 4, nasal cartilage; 5, nasal; 6, maxilla; 7, vomer; 8, squamosal; 9, pterygoid; 10, dentary; 11, angulosphenial; 12, quadratojugal; 13, mentomeckelian; 14, prootic.

processes of the adult vomers which are fused to the sphenethmoid (Fig. 5).

In the adult the vomers are extensive, irregular bones. One anterior process of each extends almost to the premaxilla in front. One pointed, lateral process ends freely. Another lateral process, just posterior to the first and also pointed, is fused to the anterior edge of the sphenethmoid of each side. The major part of each vomer extends posteriad immediately ventral to the sphenethmoid, seemingly fused to it. The vomerine teeth are borne on the end of this larger portion. The adult bones are about 1.4 mm. in length (Fig. 5).

Between 3 and 5 days after stage XX the paired squamosals make their appearance. At 5 days each is a straight elongate bone about 0.6 mm. in length arising posterior to the base of the maxilla and inclined anteriorly at approximately a 45° angle. The dorsal process which gives the adult bone its rough T-shape becomes ossified only in some specimens (Fig. 5).

By 2 weeks both the anterior and posterior projections of the dorsal cross-piece have begun to ossify. Both projections are rather short (total length of the process is approximately 0.5 mm.) and at this stage are nearly the same length. The main shaft is now somewhat longer and slightly curved dorsad, the convex side being anterior.

At 3 weeks each squamosal is about 1.9 mm. in length, straight basally but curved near the dorsal process, and still inclined anteriorly at

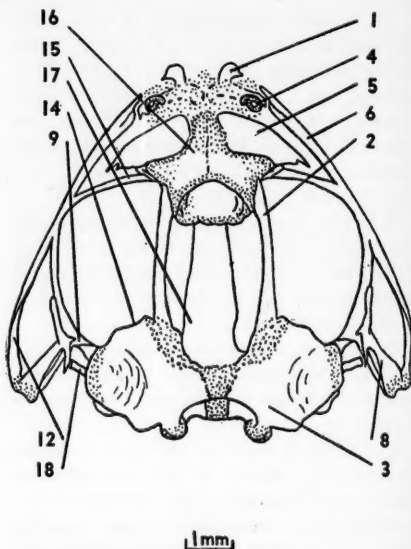


Fig. 4. Skull of adult, dorsal view. 1, premaxilla; 2, frontoparietal; 3, exoccipital; 4, nasal cartilage; 5, nasal; 6, maxilla; 8, squamosal; 9, pterygoid; 12, quadratojugal; 14, prootic; 15, palatine; 16, sphenethmoid; 17, parasphenoid; 18, columella.

about a 45° angle. The dorsal process is now about 1.5 mm. long, the anterior portion accounting for nearly two-thirds of that length (Fig. 4).

The pterygoid bones make their appearance between 3 and 5 days after stage XX. At 5 days two of the three extensions that make up each of the adult bones are ossified, the longer anterior one to the maxilla and the shorter posterior and ventral one to the angle of the jaw. Both processes are slender, with respective lengths of 0.8 and 0.4 mm. (Fig. 2).

At 2 weeks the dorsal one of the three processes may or may not be present. When present it is very short, being scarcely more than 0.1 mm. long.

By 3 weeks the dorsal process has increased to between 0.2 and 0.3 mm. in length. The anterior and posterior processes are slightly longer and much thicker. There is an especially noticeable thickening at the junction of the three. The anterior one appears fused to the maxilla, but the other two processes end freely (Fig. 3).

Each adult pterygoid is fairly stout, especially the anterior and dorsal processes. The posterior process is comparatively slender and is very closely appressed, if not actually fused, to the medial side of the base of the squamosal. The anterior process is fused to the maxilla and the dorsal one to the prootic (Figs. 4 and 5).

The two dentaries are first seen sometime between 3 and 5 days after stage XX. At 5 days each is a slender bone extending along the edge of one side of the lower jaw anteriorly, then curving medially, and finally, slightly posteriorly, apparently meeting the other dentary in the midline. Along the curve each bone is approximately 1.3 mm. in length (Fig. 2).

There is a slight thickening of the central portions and some general increase in length through three weeks. Apparently the medial tips are weakly united until about the 3-weeks stage, when they definitely are separated. At this stage the dentaries are about 2.2 mm. in length and may either be separate from or (apparently) fused to the angulosplenials (Fig. 3).

The adult dentary is almost 4.0 mm. long. The anterior median portion does not curve posteriorly and lacks contact with its partner by about 0.25 mm. (Fig. 5).

The angulosplenials first appear as a pair of ossified structures between 3 and 5 days after stage XX. At 5 days they are already well ossified and have essentially the adult form (Fig. 2). They are long, slender bones, about 2.0 mm. in length, becoming very thin anteriorly. From a point near the base of each squamosal an angulosplenial extends forward along the edge of the lower jaw. The anterior one-third lies medial to the posterior portion of the dentary and is well separated from it.

There is a general increase in length and thickness through 3 weeks, accompanied by a closer association with the dentaries (Fig. 3). The total length of each is now over 2.5 mm. The coronoid process is evident but still small. There is no definite articular surface yet formed at the posterior end of the angulosplenial.

The adult angulosplenials are over 6 mm. in length, rather thick posteriorly, but laterally compressed in the anterior one-half. The posterior-most millimeter of each is turned slightly dorso-laterad and is dorsally concave

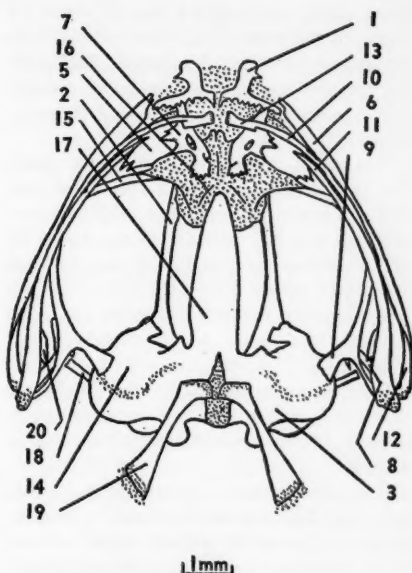


Fig. 5. Skull of adult, ventral view. 1, premaxilla; 2, frontoparietal; 3, exoccipital; 4, nasal; 5, maxilla; 6, vomer; 7, squamosal; 8, pterygoid; 9, dentary; 10, angulosplenial; 11, quadratojugal; 12, mentomeckelian; 13, prootic; 14, palatine; 15, sphenethmoid; 16, parasphenoid; 17, columella; 18, hyoid apparatus; 19, coronoid process.

where it articulates with the pterygoid and quadratojugal (Fig. 5). This dorsal, concave articular surface appears to be entirely composed of calcified cartilage. About 1.5 mm. from the posterior tip of the dorsal surface of the angulosplenial is the coronoid process which is around 0.8 mm. in length, rather low and flattened, and projects medially.

The quadratojugals are short slender bones that make their appearance from about 10 days to 2 weeks after stage XX. At 2 weeks the quadratojugal approximates 0.4 mm. in length. It lies more or less parallel and posterior to the maxilla. Its anterior end lies just medial to the posterior end of the maxilla.

At 3 weeks the quadratojugal is slightly thicker and has a length of over 0.5 mm., about half of which is closely appressed or fused to the medial side of the slender posterior end of the maxilla. The posterior end of the quadratojugal is free and somewhat rounded (Fig. 3).

An adult quadratojugal bone is about 1.5 mm. long and is completely fused to the maxilla for almost two-thirds of its length. Posteriorly the quadratojugal is rather expanded, rounded and apparently fused to the base of the squamosal (Figs. 4 and 5).

The small, paired mentomeckelian bones first become apparent about 2 weeks after stage XX and appear to be two thin calcifications of cartilage, one just posterior to the medial tip of the dentary. By 3 weeks they may be small cylindrical masses about 0.2 mm. long just posterior and partially medial to the tips of the dentaries and fused to or enclosing them (Fig. 3).

The mentomeckelians in the adult are cylindrical, about 0.6 mm. in length, apparently true bone firmly fused to the dentaries (Fig. 5).

The paired prootics appear about 3 weeks after stage XX as small, flat, roughly triangular plates of bone at the anterior medial surfaces of the auditory capsules. At this time they are about 0.5 mm. in greatest length and the posterior surface is slightly concave (Fig. 3).

In the adult the prootic is quite extensive, fusing with the occipital to form the greater part of the auditory capsule.

None of the following bones are evident at any time from stage XX through the 3 weeks ensuing: palatine, sphenethmoid, parasphenoid, columella and hyoid apparatus. Each of the above is present and well ossified in the adult frog (Figs. 4 and 5).

Erdmann (1933) pointed out that in most tetrapods ossification of the skull begins in the teeth-bearing bones or "Kieffer-apparates" but that *Rana*, and probably all anurans, are exceptions. He showed that in the pre-metamorphic period of *Rana* the first bones to appear are the parasphenoid, frontal, exoccipital, parietal and premaxillary. With the exception of the parasphenoid, these same bones appear first in *Pseudacris nigrita triseriata* (Table I). In the post-metamorphic ossification of the palatine, sphenethmoid and hyoid, *Rana* and *Pseudacris* are likewise similar. The parasphenoid, however, which is the first bone to ossify in *Rana* and appears very early in *Eleutherodactylus* (Lynn, 1942), makes a very late appearance in *Pseudacris* as well as in *Triton* (Erdmann, 1933). Since *Pseudacris*

TABLE I  
SEQUENCE OF OSSIFICATION OF SKULL BONES IN  
*Pseudacris n. triseriata*

Bone	Time of appearance in days after stage XX				
	Stage XX	3-5	10-14	14-21	21+
Premaxilla.....	+	+	+	+	+
Frontoparietal.....	+	+	+	+	+
Exoccipital.....	+	+	+	+	+
Nasal cartilage (calcification).....	+	+	+	+	+
Nasal.....	.	+	+	+	+
Maxilla.....	.	+	+	+	+
Vomer.....	.	+	+	+	+
Squamosal.....	.	+	+	+	+
Pterygoid.....	.	+	+	+	+
Dentary.....	.	+	+	+	+
Angulosplenial.....	.	+	+	+	+
Quadratojugal.....	.	.	+	+	+
Mentomeckelian.....	.	.	.	+	+
Prootic.....	.	.	.	+	+
Palatine.....	.	.	.	.	+
Sphenethmoid.....	.	.	.	.	+
Parasphenoid.....	.	.	.	.	+
Columella.....	.	.	.	.	+
Hyoid apparatus.....	.	.	.	.	+

*nigrita triseriata* has a relatively short larval period one might expect the sequence of ossification of its skull to be more like that in *Eleutherodactylus nubicola* which has no larval period. But, as seen above, the sequence of ossification in the cricketfrog more closely resembles that in *Rana* than that in either *Triton* or *Eleutherodactylus*. A great deal more observation in a number of families and genera of anurans is needed before it can be ascertained if the sequence of ossification in the skull can be of significance in showing taxonomic relationships or adaptation of embryos and/or larvae to their own peculiar needs.

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## A Kansas Pleistocene Herpetofauna

J. A. TIHEN

THE following report is based on specimens collected by field parties of the University of Michigan Museum of Vertebrate Paleontology (UMMVP), under the direction of Dr. Claud W. Hibbard, during the summers of 1947, 1951 and 1952, these specimens are now contained in the collection of that institution. They were recovered from a deposit in the Kingsdown Formation (considered a local unit of the Sanborn Formation by Frye and Leonard, 1952) of Meade County, Kansas. The fauna of this deposit has been termed the Jinglebob Fauna by Hibbard (1953). As indicated by van der Schalie (1953), this fauna is tentatively correlated with the Sangamon interglacial. The invertebrates have been discussed by van der Schalie (*op. cit.*), certain mammalian elements of the fauna were described by Rinker (1949), and Oelrich (1953) has described a new species of *Terrapene*.

I wish to express my gratitude to Dr. Hibbard for the opportunity to examine these specimens and prepare this report thereon, and for other assistance he has provided during the course of this study. I also wish to thank Dr. Edward H. Taylor, of the University of Kansas Natural History Museum, for permission to examine comparative skeletal material in the collection of that institution and in his personal collection, and for the many helpful suggestions and other assistance he has offered.

The emphasis in the present study has been on the amphibian fauna. The collections contain a very large number of snake vertebrae and a few dentigerous elements of snakes, but no study was made of these specimens. The turtle remains have been described by Oelrich (*op. cit.*). Specimens of saurian origin will be mentioned briefly, but their identifications

must be considered tentative; a more detailed study of the reptilian remains might well be productive.

The specimens were recovered by a method essentially the same as that which yielded the Upper Pliocene amphibian fauna described by Taylor (1942), and, as in that case, all elements recovered are completely dissociated, with the exception of parts of a skeleton of a *Bufo*, to be discussed later. Relative numbers of the various skeletal elements recovered were much the same as listed by Taylor, with a very large number of ilia, a large number of sacral vertebrae, a moderate number of other vertebrae and of certain limb bones, a smaller number of other limb bones and of girdle elements (other than ilia), and a very few cranial elements. Of the cranial elements, actually there are a good many maxillae in the collection, but these are mostly so fragmentary as to be of very little value. I have not counted the exact number of elements found, but there are certainly at least 100 individuals represented in the collection.

### AMPHIBIA

#### CAUDATA

*Ambystoma* sp.—Salamanders are represented by only a single vertebra. This specimen cannot be distinguished in any way from *Ambystoma* of the present day. No salamanders of any family other than the Ambystomidae have as yet been recovered from Kansas as fossils. Specific identification is impossible on the basis of this meager representation.

#### SALIENTIA

*Scaphiopus* (*Spea*) *bombifrons* (Cope).—The spadefoot toads are represented only by one

ilium and one somewhat fragmentary sacral vertebra, with the anterior portion of the fused coccyx. These appear identical with the corresponding elements in Recent *S. bombifrons*. That species is quite distinct from any other member of the genus that I have seen (*holbrooki*, *hammondi*, *hurteri*, and *couchi*) in the extensive webbing between the posterior border of the sacral diapophyses and the shaft of the coccyx. The extent of such webbing, or its absence, appears to be very constant, with only minor variations, within each species, and quite different between species. I believe the fact that *bombifrons* is not subspecifically related to *hammondi* has been clearly established, but it might be added that the skeletal differences between these two forms are of an order of magnitude that would certainly indicate specific difference.

*Bufo woodhousei woodhousei* Girard.—Toads constitute only a minor part of the present collection, but several individuals are represented. One particular specimen (UMMVP 24398) consists of a number of elements, including the presacral vertebrae, portions of most of the limb bones and girdle elements, and several skull elements, more or less fragmented, but sufficiently complete to allow an accurate reconstruction of the cranial crest pattern. This skeleton, collected by C. C. Carpenter, July 28, 1947, from Lone Tree Arroyo on the XI Ranch, is indistinguishable from large specimens of *Bufo w. woodhousei*, and is probably referable to that subspecies. It is unquestionably more similar to that subspecies than to *B. w. fowleri*.

Several individual elements in the collection are safely referable to this same form. In others there are no diagnostic characters on which to base an identification to the species level, but in none of these is there any indication that a particular element is not referable to this form. Therefore, all specimens of *Bufo* in the collection are tentatively referred to *B. w. woodhousei*.

*Acris* (?) sp.—Two ilia are definitely referable to the family Hylidae. In general, the fossil ilia appear more similar to those of *Acris* and certain species of *Pseudacris* than to those of *Hyla*, but it is difficult to pick out any specific characteristics, other than size, on which this statement is based. The tentative assignment of these specimens, and one tibiofibula, to

*Acris* rather than to *Pseudacris* is based on the probability that individuals of the former are more likely to be preserved because of their habits.

*Rana catesbeiana* Shaw.—A few portions of ilia and, tentatively, one or two other elements, are referred to this or at least a very closely related form, on the basis of their size, form, and structure of the bone. The bone exhibits the very porous, almost sculptured, consistency typical of this species particularly, and to a lesser extent of related forms such as *R. heckscheri* and *R. grylio*.

*Rana pipiens* Schreber.—Probably 90 percent of all the amphibian specimens in the collection have been referred to this species. A large number of the individual elements could not, of course, be definitely associated with this form of themselves, but since so many of the identifiable specimens could be so associated, it seemed most reasonable to assume that all specimens of *Rana* not inherently inconsistent with identification as *pipiens* could be assigned to that species with a high percentage of accuracy. There are a very few specimens which have not been referred either to this form or to *catesbeiana*, but these are not uniform among themselves, and cannot be identified closely with any of the other living species I have seen. The presence of other species of frog would not be surprising, but in view of the inability to associate these specimens with any particular Recent form, or with each other, I think it more probable that they simply represent extreme variants of *pipiens*.

In view of the importance which attaches to the sacral vertebra as a criterion for the identification of fossil ranids, it is perhaps pertinent to insert here a few observations on the variation encountered in this element in the Recent forms used as comparative material. These specimens were not examined with the intent of studying variation *per se*, but simply to provide a basis for identification of the fossil specimens. The numbers involved are not sufficient to allow any sort of meaningful statistical analysis, but are strongly indicative of certain variational patterns which can be confirmed or disproven (and measured) by a more detailed and extensive study.

Any differences in proportions that can be recognized subjectively should be as readily, and more accurately, recognizable on the basis

of properly chosen objective measurements. This is certainly true if such objective measurements can be made with sufficient accuracy, but the difficulty of obtaining accurate measurements on objects of such small size and irregular shape is obvious. And a small error in absolute measurements can lead to a rather large error in proportions calculated from such measurements. In many instances, I do not believe errors of rather great magnitude can be avoided without the use of measuring techniques so time-consuming as to be impractical for a work of the present nature. Certain features which appear rather clear-cut and readily recognizable on subjective examination will, from objective measurements taken by ordinary techniques, appear quite variable within a species and show a great deal of overlapping between species. I believe many such features are accurately recognizable subjectively, and that if accurate measurements were to be made, would show the intra-specific variation to be much less, and the inter-specific differences to be much more clear cut, than would be indicated without the use of special measuring techniques. As stated above, careful work of this nature is beyond the scope of the present study, and I have not hesitated in using certain subjective characteristics as aids in identifying the fossil specimens.

One of the more interesting variational trends noted involves the length of the centrum (including condyles) relative to its greatest width, usually at the condyles. Apparently three factors must be taken into account: individual variation within each species, differences between species, and a change within each species correlated with age, or at least with size. Within every form in which specimens of varying sizes were examined, there is a definite increase in the relative length of the centrum in the larger individuals. Therefor, although there may be a great deal of overlap between two different species in respect to this proportion, if the proportion be plotted against some indicator of size, such as the length of the centrum, then separation between the two forms may be shown to be virtually complete.

*Rana pipiens* was compared with *calesbeiana*, *grylio* and *heckscheri*. No noticeable differences in this feature could be found among the last three species, and the larger number of

points obtained by using all three gives, I believe, a more complete picture of the correlation between size and proportions. The indication that the fossil sacrum might be slightly shorter than that of living *pipiens* is probably a reflection of the frequent partial erosion of the articular surfaces, rather than an actual difference (Fig. 1).

A straight line, drawn empirically, separates *pipiens* from the bullfrogs (Fig. 1). This same line may almost equally well separate two large aggregations of American species. There is some indication, though, generally, the number of specimens involved is too small to warrant a definite conclusion, that every species I have examined will fall pretty well above or below this line, with none having a really intermediate range of variation. Thus, *R. clamitans*, *R. palustris*, *R. sylvatica* and *R. virgatipes* appear to have about the same variational pattern as *pipiens*, while *R. capito*, *R. areolata*, and *R. septentrionalis* seem comparable to the *grylio-heckscheri-calesbeiana* group. The significance of such grouping, if it does exist, is not at all clear.

Another feature in which definite interspecific differences are complicated by intraspecific variation correlated with size is the extent of separation of the coccygeal condyles, as compared with the total condylar width (Fig. 2). The condyles are relatively small and widely

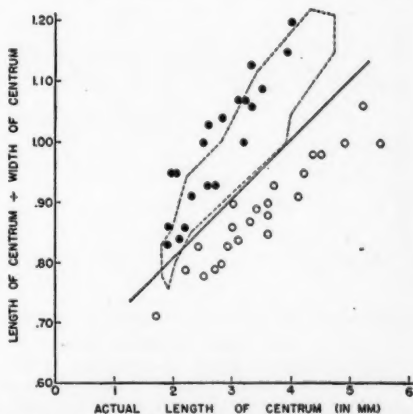


Fig. 1. Relative width of the sacral centrum in *Rana pipiens*, *R. calesbeiana*, *R. grylio* and *R. heckscheri*. Width of the centrum is at the condyles. Dots represent *R. pipiens*; circles, the other three species. Dashed line encloses the total range of variation in the fossil population.

separated in young individuals, becoming larger and heavier, and relatively much closer together, in older ones. In addition, those of *pipiens* are closer together than are those of members of the *atesbeiana* group of comparable size. The extent of variation within a species, and the overlap between species, both appear greater in this character than in the preceding one, but the absolute measurements used in calculating this ratio are smaller, and I believe that errors in measurement are largely responsible for this. There is a close similarity between fossil and Recent *pipiens*.

The angle formed by the posterior borders of the diapophyses, produced until they meet, is also subject to some age variation. In the very young of all forms, this angle is relatively obtuse, becoming more acute as the animal grows larger. Most of the change takes place in the early stages of growth, and there is little or no further change after a certain point has been reached. This angle is rather acute in *pipiens*, as compared with most forms.

Other features that appear to be useful aids in identifying sacral vertebrae include the distance which separates the zygapophyses from each other and the orientation of their articular surfaces, the shape of the ventral surface of the centrum and that of the neural canal. Some species also have special identifying features, which may or may not be shared

with other forms, such as the porosity or sculpturing of the bone in *atesbeiana*, shared to a somewhat lesser degree with *grylio* and *heckscheri*, or an extensive longitudinal depression on the ventral surface of the centrum, found occasionally as a variant in several forms, consistently and characteristically in others.

My observations tend to confirm the opinion expressed by Taylor (*op. cit.*) that, considering both the probability of recovery and the number of diagnostic or semi-diagnostic characteristics likely to be exhibited, the sacral vertebra is the most appropriate single element to utilize in the description of fossil forms. However, a number of factors must be taken into consideration in interpreting the characteristics presented by any particular specimen or group of specimens.

## REPTILIA

### SAURIA

*Holbrookia* (?) sp.—One nearly complete maxilla is tentatively identified as belonging to this genus. It is certainly an iguanid, and differs from most iguanid genera in several respects. It also differs in details from any particular specimen seen of any members of the genera *Holbrookia*, *Uma*, and *Callisaurus*, or of *Sceloporus* and *Uta*, both of which it approaches closely in general form. It appears more closely associated with *Holbrookia* than with *Sceloporus* or *Uta* on the basis of the number of teeth. This specimen probably bore only 17 teeth, while the minimum number observed in any member of the *Sceloporus-Uta* group was 19.

*Sceloporus* (?) sp.—One pelvis, with the greater part of the ilium and the acetabular portions of the ischium and pubis, is probably safely referable to this genus.

*Eumeces* sp.—An incomplete dentary can be definitely referred to the genus *Eumeces*, but the specific allocation remains uncertain. In many respects it resembles *E. obsoletus*, a form inhabiting the same area at the present time.

Other reptilian remains.—Several lizard (iguanid) vertebrae are present in the collection. There are many snake vertebrae, a few dentigerous elements of ophidian origin, and a few caudal vertebrae of a turtle. Because of my lack of familiarity with the details of the

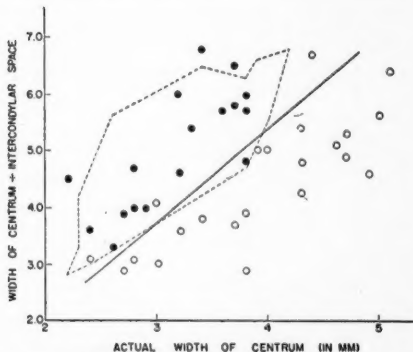


Fig. 2. Relative degree of separation of the sacral condylar stalks from each other in *Rana pipiens*, *R. atesbeiana*, *R. grylio* and *R. heckscheri*. Width of the centrum is the width at the condyles; intercondylar space is the distance between inner edges of the condylar stalks. Dots represent *R. pipiens*; circles, the other three species. Dashed line encloses the total range of variation in the fossil population.

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osteology of Recent forms in these groups, I am unable to offer even a tentative identification of these specimens.

#### GENERAL REMARKS

The most interesting feature of this herpetofauna, so far as it has been identified, is its strong similarity to the living assemblage of this same region. There is not a single specimen in the entire collection which can definitely be referred to some form not now inhabiting this same area. An exception, of course, is *Terrapene llanensis*, described by Oelrich (*op. cit.*). The range of most of these forms is so widespread that their presence here provides little information concerning climatic conditions at the time of deposition of the fossiliferous deposits. In general, they at least do not conflict with the evidence presented by the mammalian and molluscan faunas that the climate at that time was warmer and more humid than at present. One possible exception is the presence, if verified, of *Holbrookia*; the correctness of this identification is so uncertain, however, that little weight can be given it. The absence of any elements definitely referable to such forms as *Phrynosoma* and *Bufo cognatus*, both very common in that region today, might be indicative of less arid conditions, but negative evidence of this sort should be taken into account only with very strong reservations.

Evidence has been accumulating for some time that many of the Recent amphibian genera were already in existence relatively early in the Tertiary. Several extant species have been identified in the Pleistocene, and there is now at least an indication that some Pleistocene forms

may not have been distinguishable even subspecifically from their living descendants. Inability to distinguish the Sangamon *Bufo* herein described from the present day *B. w. woodhousei*, on the basis of material available, is no sure indication that subspecific differences did not exist. But Recent *B. w. woodhousei* can be distinguished from other subspecies osteologically, and the fossil form can likewise be distinguished from the other living subspecies of *woodhousei*. So it can safely be stated at least that, as far as skeletal characteristics are concerned, this Sangamon form is more similar to the subspecies now living in the same area than are the existing subspecies to each other.

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## Herpetological Notes

A RANGE EXTENSION OF THE SALAMANDER *GYRINOPHILUS PORPHYRITICUS* *PORPHYRITICUS*.—An adult of *Gyrinophilus p. porphyriticus* (Green) was collected by the writer on April 2, 1953, in Blount County, Alabama. The locality was approximately 3 miles north of Warrior, and one-half mile north of the road running east to Hayden, in a deep ravine lying east of and parallel to U.S. Highway 31. The animal was 150

mm. in total length, 18.5 from snout to gular fold, and 67.5 from snout to vent. There were eleven white spots on the venter indicating possible parasitization.

A steep rocky tributary to the valley stream passes under the highway through a large rock-and-cement culvert, and a spring-alcove environment is simulated where it emerges. The situation is permanently shaded, cool, and mossy. The *Gyrinophilus*

was found in a mass of wet twigs and leaves. Many individuals of *Desmognathus fuscus fuscus* also were found, under rocks in the same location and along the margins of the main stream. The vegetation of the ravine consists of second-growth mixed forest, with deciduous trees occurring more abundantly on the valley floor and pines (probably *Pinus echinata*) on the slopes. The herb layer is fairly well developed, but the shrub layer is poorly represented. The stream flows south through Double Creek to the Locust Fork of the Black Warrior River.

This locality record confirms Bishop's statement that the range of *porphyriticus* "possibly" extends to Alabama. It is, however, over 100 miles southwest of the southwestern margin of the range shown in his map (Bishop, 1943, Handbook of salamanders) Dunn cited a record for Jackson County, Alabama, in the northeast corner of the state (1926, The salamanders of the family Plethodontidae). It is not surprising that an animal which occurs throughout almost all of the Appalachian Plateaus Province, from New York to Tennessee, should also occur in the Alabama part. *G. porphyriticus* may quite likely be found in suitable habitats through much of the Black Warrior drainage almost to Tuscaloosa.

Other records further extend the range, as shown by Bishop, east into eastern Tennessee (Reese, 1950, Chicago Acad. Sci. Nat. Hist. Misc. 63:1-7) and north of the Vermont border into Quebec (Hall, 1947, COPEIA (1): 68). The extent of reinvasion of glaciated territory may be greater than is now known.—GORDON R. THUROW, *Department of Zoology, University of Indiana, Bloomington, Indiana.*

**THE ALLIGATOR IN ARIZONA.**—The range of *Alligator mississippiensis* was stated by Reese (1915, The alligator and its allies: 9) as "from the southern part of North Carolina to the Rio Grande, though Florida is usually thought of as being the region in which they particularly abound." Ditmars (1946, The reptiles of North America: 5-6) characterized the habitat preference as being the rivers and swamps of the low coastal region from North Carolina, throughout Florida, and westward to the Rio Grande in Texas. Blair (1950, COPEIA (1): 57) reported an 8½-foot alligator from extreme eastern Oklahoma, near the Arkansas border. He thought this size supports the view that this is a natural occurrence (plus the fact that the southeastern part of the state presents proper habitat), in contradistinction to occasional reports throughout the state which attest to the distribution of the alligator by man. It will appear later that this is not necessarily true.

Certainly the aquatic preferences of the alligator are well known, so that on two counts (discontinuity of range, and paucity of preferred habitat) the alligator is not to be expected to emerge as a member

of the Arizona fauna. The fact that many other exotic animals are being added to the biota of Arizona will serve to introduce the explanation of the occurrence of this reptile some 1,000 miles from its normal range. Among the many introduced forms are bait fishes (Miller, 1952, California Fish and Game, 38: 7-42), soft-shelled turtle (Miller, 1946, COPEIA (1): 46), and the Virginia opossum (Hock, 1952, Jour. Mammal., 33: 464-70).

The first alligator record for Arizona of which I have first-hand knowledge was a young, live specimen given to me in the fall of 1949 by William H. Woodin, III, of Tucson. Woodin, then one of my students at the University of Arizona, has a long interest and considerable reputation as a herpetologist. This alligator had been reported to him as a "lizard" living in an irrigation ditch. He secured the specimen, and had had it for some time before giving it to me. It was then 14 to 16 inches long, and was still alive at the University when I left there in June, 1950. It seems obvious that someone had tired of a "mail order" baby alligator, and had released it in a convenient ditch.

The second record is explainable on a different basis. It was a specimen 5 feet long, and was lassoed by a sheriff's deputy in a tourist court on the outskirts of Tucson in the spring of 1950. This animal was given to me, and was very weak and dehydrated. It was kept captive in the Department of Zoology at the University for several months, and was in fine condition when I left. The facts of this record emerged as follows: a carnival company had come into possession of this animal some 2 years before in Tucson, apparently because another carnival had gone bankrupt. Perhaps due to the fact that the alligator had lost its attraction on their circuit, or because it was burdensome to transport, the company decided to let the animal go, and chose Tucson as a fitting locale.

The third record may be explainable on either basis given above. I am indebted to Dr. Robert R. Miller, of the Museum of Zoology, University of Michigan, for first telling me of this occurrence. Mr. Tommy Kinder of Parker, Arizona has, at my request, sent me details of this record. I wish here to thank him for his efforts. However, I later found that he had written an article describing this matter (1945, Arizona Wildlife, 6 (3):5) and I use here the facts as set forth in the publication.

In June, 1943, Kinder was bass fishing with a friend in the Colorado River below Parker when he first saw the alligator. He returned a few days later and shot at the 'gator 18 times, with several hits. Finally, it sank and was seen no more.

About a month later, Kinder returned with his wife and daughter. While he was plugging for bass, he heard his wife scream and found that the alligator had come in the water to within 10 feet of his wife

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and child on the shore. Kinder and his companion looked for the 'gator, but could not find it. A few days later he returned to the place, known as Lost Lake, and found that the animal had been shot by Martin Hoover, of Blythe, California. Bones and pieces of hide were all that remained.

The 'gator was 10 feet, 4 inches long. It had been lying on the sand when shot, and had bullet scars on it. It is therefore presumably the same one wounded by Kinder.

A photograph taken by Hoover was reproduced by Kinder (1945), and he has sent me another picture. It is obvious from these that the animal is *Alligator mississippiensis*. My estimate of its length from the photo was 10 feet, 6 inches, before I read in Kinder's article the measured length.

Before receiving Kinder's letter I had speculated as to whether or not this saurian had been released as a small animal, like the first occurrence mentioned above. If this were the case, a long sojourn in the Colorado must have been passed, for the time necessary for growth from "pet" size to a 10- to 12-foot alligator is considerable (McIlhenny, 1935, The alligator's life history). It therefore seemed reasonable that the reptile was released by a carnival, as was the second occurrence given above, or by one of the roadside zoos so unfortunately common in Arizona.

Kinder's letter resolved these speculations, and I quote from it: "'gators were dropped in [the Colorado] at Parker RR bridge at Ferry Landing years ago by a traveling carnival who didn't want them any more."

In addition, there were some small alligators at the Santa Fe Railroad roundhouse at Needles, California, which became too large for their fish pond, and were released. This was before Parker Dam was built (the dam was completed in 1938). Kinder used to operate the ferry at Parker, and several times saw a small alligator in the River. One of these animals may well have been that on which this record is based.

Kinder has been told by the Indians that another large 'gator is in La Paz Slough, 35 miles south of Parker. This is probably one of the animals released in the two incidents here recorded, or in some similar set of circumstances.

It would appear that there is a possibility that alligators may become established in Arizona as residents of the state, as long as these haphazard and ill-conceived introductions are allowed to continue. The species is only one of a rapidly lengthening list of exotic animals that are spreading over Arizona. Perhaps a fate similar to that of the bizarre endemic Hawaiian birds will befall the interesting and often unique animals of the state, due to unfortunate introductions, unless some competent

authority soon supervenes.—RAYMOND J. HOCK, Arctic Health Research Center, U.S. Public Health Service, Anchorage, Alaska.

#### THE SALAMANDER *AMBYSTOMA TIGRINUM NEBULOSUM* IN SOUTHERN ARIZONA.

—Two adults of *Ambystoma tigrinum nebulosum* were secured on August 29, 1952, in southern Arizona. Of especial interest, they afford new information on the subspecific identity of the tiger salamanders of this area. Heretofore, only the larvae have been reported with definite data (Reed, 1951, Nat. Hist. Miscell., Chicago Acad. Sci., 79: 1-3).

These two were collected on the east side of Horse Cienega, one mile north-northeast of Hannagan Meadow, Greenlee County, Arizona. This is in the White Mountains at an elevation of 9000 feet. This cienega may be best described as a shallow basin of about 50 acres surrounded by heavily timbered hills. A small pond about 20 feet wide was in the center.

The two salamanders were found together in a gopher (*Thomomys bottae grahamensis*) tunnel. They were lying against a boulder 4 inches below the surface and 7 feet from the nearest opening.

One specimen, possibly a female, measured (living) 98.3 mm. from snout to anus, and 76.4 from anus to tip of tail, a total length of 174.7. Its dorsal and lateral ground color was a yellowish green with irregular, dimly defined, silvery white blotches. Unfortunately, this individual escaped during transport. The other specimen, possibly a male, measured (living) 99.7 mm. from snout to anus, and 82.2 from anus to tip of tail, a total length of 181.9. Its ground color, in contrast to that of the other salamander, was a very dark olive green with irregular, dimly outlined blotches a shade lighter than the background. This specimen was kept in captivity for 7 months on a diet of insect larvae and earthworms. It is now University of Illinois Museum of Natural History No. 33819. It appears to be a typical representative of *A. t. nebulosum* Hallowell, since it possesses only a very dim, irregularly blotched pattern. Possibly the larvae reported by Reed (*op. cit.*) represent the same subspecies. Regardless of the identity of the latter, however, the known range of *A. t. nebulosum* is extended about 150 miles southward by the present specimen. If a spotted race occurs in southern Arizona at all, as is suggested by some vague records noted by Dunn (1940, COPEIA (3): 161-2), its range must be limited to the extreme southeastern corner of the state.—ROBERT T. CALEF, Museum of Natural History, University of Illinois, Urbana, Illinois.

A DEFENSE DISPLAY IN THE SALAMANDER *AMBYSTOMA JEFFERSONIANUM*.—While collecting Jefferson's salamander, *Ambystoma jeffersonianum*, near Chesterton, Indiana, in

September, 1952, and April, 1953, I noted what appears to be an unrecorded defense behavior.

The salamanders were found under logs in a wooded bottom land along streams. When exposed, the salamanders first remained still, then attempted to reach other cover. When escape was blocked and the salamanders were touched roughly, the small and medium-sized individuals usually behaved as follows: The tail was raised until it was vertical; the hind legs were spread and braced, the vent off the ground; the body was held still, the head on the ground, the front legs bent; and the tail was undulated, with the waves starting at the base and traveling to the tip, quite rapidly but not violently.

If left alone, this movement slowed down and the tail either straightened out behind or gradually leaned over to one side until the tip touched the ground. However, if the animal was stimulated further during the display, the body was bent suddenly so that the head was placed close to the base of the erect and undulating tail. During the display the dermal glands that are well distributed over the tail (but not those on the body) exuded a sticky, white substance.

More than a hundred of these salamanders were found. While most of the small and medium-sized individuals performed as described, the larger individuals had a much less marked display, presumably because of the proportionately larger and heavier tail.

When the salamanders were brought into the laboratory, attempts to elicit this display were unsuccessful, or brought forth only a slight indication of it.

This display may be defensive, though just how it functions and against what is not clear. A number of salamanders lose their tails when seized, and some, for instance *Ensatina*, have a basal constriction, apparently to facilitate this. The tail in Jefferson's salamander seems as firmly attached as most. Perhaps the display attracts a predator's attention to the least essential and most easily spared part of the animal.—A. STANLEY RAND, *Chesterton, Indiana*.

**THE KINGSNAKE *LAMPROPELTIS GETULUS HOLBROOKI* PREYING ON THE CARDINAL.**—During midmorning, July 19, 1951, 2 mi. west of New Orleans, in Jefferson Parish, Louisiana, I observed a pair of cardinals, *Richmondia cardinalis magnirostris*, in a state of great agitation fluttering about and alighting on a clump of Spanish moss 6 or 7 feet above the ground; the clump was entangled in a vine which had grown up from the ground along the branches of a small hackberry tree. I approached closely and found a kingsnake, *Lampropeltis getulus holbrooki*, between 3 and 4 feet

long, in the clump of moss, vibrating its tail against the vine. There was an empty nest in the moss clump, and the snake had in its mouth a young cardinal which was mostly unfledged but with partly open pinfeathers on the wings and tail. The snake had grasped the bird in the scapular region, not by the head. When I took hold of the snake near its tail, it dropped the bird, which started cheeping loudly. In the tangle of the thorny vine I failed to get a good grip on the snake and it escaped. I was able to see that it had no lumps in its body and so could not have eaten any other young cardinals just prior to its present attempt. The bird appeared to be uninjured although wet with saliva where the snake had grasped it, and I replaced it in the nest. As little has been published on the food habits of *L. g. holbrooki*, this attempt to prey on a nestling cardinal seems worthy of record.—THOMAS R. HOWELL, *Department of Zoology, University of California, Los Angeles, California*.

**NOTES ON THE HERPETOLOGY OF AN ALGERIAN BEACH.**—In view of the scarcity of herpetological records from the Algerian littoral, the following observations may be of interest. Between the 7th and the 17th of June, 1953, a collection was made in the neighborhood of Bougie, a seaport 120 miles east of Algiers. During this period temperatures were rather low for the time of year, ranging from about 65° F. at night to 85° at midday, and there were several heavy rainstorms.

One species of amphibian and ten species of reptiles were obtained from the strip of beach bordering Bougie Bay, a few miles east of the town itself. This beach, which faces northeast, forms a well defined ecological region, and is separated from the hilly country farther inland by a coastal road. In most places the beach is from a quarter to a half mile wide and shows three partly distinct zones. Nearest the sea is a "maritime" zone, which includes the narrow tidal area, and is about 20 yards in width. This zone has a surface of pure sand and supports a maritime flora including marram grass, horned poppy and sea-holly. Farther inland is a wide "intermediate" zone where the sand is partly mixed with earth. Here the dominant plants are *Lentiscus* bushes (mostly at the junction between the "maritime" and "intermediate" zones), agave, tamarisk and *Centaurea*. Occasional date palms are scattered about. In places the ground is littered with fallen agave leaves, and there are a number of logs and boulders. Nearest the road is an "inland" zone of more or less cultivated ground, cornfields and vineyards, often in a state of reversion. In places along the beach there are patches of richer vegetation which extend across the "inland"

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and "intermediate" zones and are often associated with streams; in such places oleander bushes, broom and Mediterranean pine grow abundantly.

The species described below were obtained in the beach area. Alternative names, given in square brackets, are those used by F. Doumergue whose paper (1901, *Extrait du Bulletin de la Société de Géographie et d'Archeologie d'Oran*: 19-21) is a standard work on North African herpetology, though it does not deal with the actual region visited by us.

#### LIST OF SPECIES

*Bufo mauritanicus* Schleg.—Adult specimens of this toad were found under stones in the beach "inland" zone.

Tadpoles and newly metamorphosing toadlets were abundant in some of the streams which crossed the beach and in the wide shallow pools in which these streams ended, only a few yards from the sea. Although these pools were not actually continuous with the sea, at least above the surface of the sand, they were exposed to the spray; their salinity was presumably higher than that of the streams further inland.

The occurrence of tadpoles of *Bufo viridis* Laurenti in brackish water has been recorded (K. P. Schmidt, 1951, *Marine Life*, 1 (9)). This toad is also common in North Africa. Doumergue remarked, without comment, that in salty pools the tadpoles of *B. mauritanicus* feed on saltwort (*salicornes*) but he did not mention their living near the sea. Indeed, he regarded *B. viridis* as the common coastal form and observed that this species is replaced by *B. mauritanicus* farther inland. The identification of our tadpoles is therefore a matter of interest. Doumergue stated that newly metamorphosed tadpoles of *B. viridis* measure about 20 mm. and are much larger than those of *B. mauritanicus*, which measure 10-11 mm. Our newly metamorphosed toadlets are about 12 mm. in length from snout to disappearing tail-tip. For this reason, and because they possess paired and not single subarticular tubercles on the toes, they seem very probably to belong to *B. mauritanicus*. Identification of the adult toads spawning in beach pools in this area is necessary, however, before *Bufo mauritanicus* can certainly be added to the list of those amphibians whose larvae may inhabit slightly saline water.

No frogs were found on the beach area proper, but *Rana ridibunda* Pallas was common in the streams on the landward side of the coastal road.

*Acanthodactylus vulgaris* Dum. & Bib.—This small lacertid is very common all along the beach, particularly in the "intermediate" and "maritime" zones; in the latter it was the only reptile found.

*Psammoudromus algirus* (Linn.).—Some specimens were seen in the "inland" zone along the edge of the road, but this lacertid is much more common farther inland.

No lizards of the genus *Lacerta* were seen near Bougie although they occur in other parts of Algeria and are common on the European coast of the Mediterranean.

*Chalcides ocellatus* (Forsk.). [*Gongylus ocellatus*].—These skinks are common among boulders and under logs and fallen agave leaves, in the "inland" and "intermediate" zones. Females often contained eight or more eggs with embryos.

*Chalcides tridactylus* Laurenti [*Seps tridactylus*].—One specimen of this anguimorphine skink was taken in a field of grass and stubble bordering the road.

*Tarentola mauritanica* (Linné.).—The Mauritanian gecko is not uncommon in the "inland" zone and seems to show a special partiality for concrete surfaces. It was found around the mouths of conduits passing beneath the road, and on the supports of the small, uncompleted bridges which were built before the war for a railroad intended to run along the beach. Geckos were seen abroad throughout the day.

*Trogonophis weigmanni* Kaup.—About 15 specimens of this amphisbaenid were taken under stones, often in the neighborhood of *Lentiscus* bushes, just inside the seaward border of the "intermediate" zone. Its distribution seems to be extremely localized and all the specimens from this beach were collected within a few hundred yards of Tichy, a village about 10 miles east of Bougie. *Trogonophis* was found in much greater numbers on the beach at Castiglione, about 20 miles west of Algiers. The collection of amphisbaenids was the principal object of the expedition, and it is hoped to publish more extensive observations on this species later.

*Eryx jaculus* (Linné.).—One specimen of the javelin sand boa was captured beneath a log and another was seen but not taken. Both specimens occurred in a part of the "intermediate" zone about 6 miles east of Bougie in which other reptiles were relatively scarce. Two other examples of this snake were taken by one of us on the beach about 3 miles farther east in September, 1943. The occurrence of *Eryx* near Bougie is of interest since it is generally believed to be scarce in the north of Algeria. Crepuscular or nocturnal collecting might indicate that it was commoner than our experience would suggest.

*Coluber hippocrepis* Linné. [*Zamenis hippocrepis*].—This colubrid is quite common on the beach in the "intermediate" and "inland" zones.

*Natrix maura* (Linneé). [*Tropidonotus viperinus*].—Two specimens of the viperine snake were taken in the "inland" beach zone among stones. It is probably commoner in the streams farther inland.

*Macropododon cucullatus* (Geoffr.).—One juvenile specimen of this opisthoglyph was captured among a pile of stones in the "intermediate" zone.

A large snake probably *Malpolon m. monspessulanus* (Hermann) [*Coelopeltis monspessulanus*] was seen at the edge of a cultivated field near the road, but could not be certainly identified.

A .22-caliber pistol loaded with dust-shot cartridges proved invaluable for the collection of lacertids and geckos. It was effective up to a range of about 12 feet and did surprisingly little damage to the specimens.

We should like to express our thanks to the Trustees of the Durham Fund, King's College, Cambridge, for a grant towards the expenses of the expedition, and to the staff of the Marine Laboratory of the Zoology Department, University of Algiers, for assistance in many ways. We are also indebted to Mr. J. C. Battersby and Miss A. G. C. Grandison of the British Museum (Natural History) for help in identifying our specimens.—A. D'A. BELLAIRES AND C. C. D. SHUTE, *Department of Anatomy, University of Cambridge, Cambridge, England*.

**RANA PALUSTRIS IN ALABAMA.**—The range of *Rana palustris* in Georgia seems to be limited to the Upper Austral Zone, although in North Carolina, Louisiana, and Texas it extends on to the Coastal Plain. In Alabama, the species has been collected from the Upper Austral life zone near the summits of Mt. Cheaha in Clay County, and Monte Sano Mountain in Madison County. In these localities, it is found sparingly in cool mountain streams. On August 9, 1953, the authors visited Saunders Cave, near Brooklyn in Conecuh County. This large, damp, cool, limestone cave, with side passages, is located on the Lower Coastal Plain. Eight *Rana palustris* were collected in the twilight zone of this cave and several others were seen retreating into crevices. These represent the first record of this species from the Lower Coastal Plain in Alabama. Extensive collecting throughout the state has produced no records other than those mentioned above, an indication that discontinuous populations occur in Alabama. Careful comparison of the Conecuh County specimens with those from other localities in Alabama and from New York failed to show any noticeable differences. The lower Coastal Plain is characterized by hot, dry summers in contrast to the Upper Austral zone. Apparently the Saunders Cave population is able to endure the hot weather by retreating to the cave in the summer. A small, clear stream flows near the mouth

of the cave, and it is possible that breeding in the winter may take place here. Specimens from the above three localities are in the University of Alabama collections.—JACK S. BROWN AND HERBERT T. BOSCHUNG, JR., *Department of Biology, University of Alabama, University, Alabama*.

**NOTES ON THE FROGS AND TOADS OF LABRADOR.**—The following notes are based on collections and observations made during the course of the BLUE DOLPHIN Labrador Expeditions of 1949–1951. These expeditions were supported by the Arctic Institute of North America with funds provided by the United States Government, and by funds from private sources.

During the course of the three summers' expeditions, scientific observations were made along the Labrador coast from the Strait of Belle Isle north to Kangalaksiorvik Fjord (59°25' N). Considerable time was spent in the Hamilton Inlet—Lake Melville estuary including the lower stretches of the chief tributaries. In 1951 a week was spent on the Labrador plateau at a point above Grand Falls on the Hamilton River. Although the study of Labrador's herpetofauna was not an objective of these expeditions, such amphibians as were encountered were usually collected. Four species of Salientia were observed in Labrador. On no occasion during the three summers did we see or hear reports of salamanders, snakes, turtles or lizards, nor are there any valid literature records from Labrador for species in these groups.

*Bufo terrestris copei* Yarrow and Henshaw.—The northernmost record to the eastward for this toad, which is distributed throughout central Quebec and northeastern Ontario, is from Salmon Bay in the Strait of Belle Isle. This record (Packard, 1866, Proc. Boston Soc. Nat. Hist., 10: 272) has generally been overlooked. The following records extend the range of this species somewhat farther to the north and show it to be common in central Labrador.

St. Mary's River, St. Lewis Inlet (52°18' N, 55°54' W) on July 12, 1949, 3 specimens, 66, 66 and 70 mm. long from snout to vent after preservation. Three miles below Muskrat Falls, Hamilton River (53°13' N, 60°43' W) on July 19, 1951, 1 specimen, 58 mm. long. Mouth of the Hamilton River (53°15' N, 60°11' W) on August 23, 1950, 1 specimen, 54 mm. long. North West River, Lake Melville (53°32' N, 60°09' W) on July 4 and 5, 1949, 3 specimens, 62, 67 and 68 mm. long; similarly on August 23, 1949, 1 specimen, 58 mm. long; similarly on July 10, 1950, 1 specimen, 54 mm. long; and similarly, on July 7, 1951, 1 specimen, 71 mm. long. Epinette Pt., Lake Melville (53°32' N, 59°54' W) on July 7, 1951, 1 specimen 67 mm. long. Ettagaulet Bay, Lake Melville (53°43' N, 59°01' W) on July 20, 1951, 3 specimens, 56, 56 and 61 mm. long. Pike Run Cove,

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Lake Melville (54°06' N, 58°19' W) on July 21, 1951, 1 specimen, 58 mm. long.

On August 24, 1949, 24 tadpoles of this species 18 to 23 mm. in length from snout to tip of tail were collected from a ditch at the edge of Little Lake, North West River. These tadpoles were just beginning to transform, the hind legs being from 1 to 1.5 mm. in length. The water temperature of Little Lake at this time was about 60°F.

On the Labrador plateau at Flour Lake (53°43' N, 64°35' W) a specimen of this species was observed but not collected during the last week of August, 1951. It is probable that this species is distributed throughout the forested portions of Quebec and Labrador.

*Rana sylvatica cantabrigensis* Baird.—This woodfrog, which is distributed across northern North America from Alaska to Labrador, was reported from Okak, Labrador by Packard in 1866 (Proc. Boston Soc. Nat. Hist., 10: 272). Recently Hildebrand (1949, COPEIA (3): 168-72) reported specimens from Fort Chimo, Quebec. The BLUE DOLPHIN collected the following specimens:

Mud Lake, Hamilton River (53°15' N, 60°11' W) on August 23, 1950, 1 specimen, 18 mm. long; similarly on July 7, 1951, 6 specimens, 43, 45, 46, 46 and 47 mm. long. North West River, Lake Melville (53°32' N, 60°09' W) on July 10, 1950, 3 specimens, 40, 44, and 46 mm. long.

*Rana septentrionalis* Baird.—The distribution of the minkfrog has recently been reviewed by Moore (1952, Amer. Nat., 826: 5-22). The known range of this species then indicated a northern limit at about latitude 50° north. The northernmost record to the eastward was from Godbout, Quebec (49°20' N). A specimen 68 mm. long collected at Etageau Bay, Lake Melville (53°43' N, 59°01' W) on July 11, 1950 extends the range of this species about 450 miles towards the northeast. This makes it likely that the uncertain record of Cope (1889, Bull. U. S. N. M., 34) for Moose River, James Bay, and the sight record of Williams (1920, Canadian Field Nat., 34: 125) from Moose Factory, James Bay, are valid and that there exists a more northern limit to the minkfrog's range than Moore predicates.

*Rana pipiens pipiens* Schreber.—The following collections of the meadowfrog were made by the BLUE DOLPHIN: Mud Lake, Hamilton River (53°15' N, 60°10' W) on July 27, 1950, 4 specimens, 64, 66, 66 and 73 mm. in length. Mouth of the Hamilton River (53°15' N, 60°11' W) on August 23, 1950, 1 adult, 70 mm. long; 6 juveniles recently transformed, 31 to 34 mm. long; and 23 transforming tadpoles, 60 to 85 mm. long from snout to tip of tail. Rabbit I., Goose Bay (53°24' N, 60°09' W) on July 11, 1951, 1 specimen, 38 mm. long.

The least developed of the tadpoles listed above

are specimens with hind legs 4 mm. long. All stages of transformation beyond this are represented.

On the North American mainland the northern limit of *Rana pipiens* in the east as shown by Wright and Wright (1948, Handbook of Frogs and Toads: 498) is likely correct, although there are few if any specific records for localities in easternmost Quebec and Labrador. However, the inclusion of Newfoundland in the range of this species (map and text) as well as in the range of *Rana clamitans* (map) is incorrect, as it is not explained that these species have been introduced into Newfoundland. Newfoundland appears to have been completely glaciated as an island and thus has a much impoverished fauna consisting only of those animals which have been able to cross the saltwater (or sea ice) barrier which is a minimum of 9 miles in width in the Strait of Belle Isle. Thus Newfoundland has no native herpetofauna, no freshwater fishes in the strict sense and no small mammals except *Rattus rattus*, *Rattus norvegicus* and *Mus musculus*, all introduced; and *Microtus pennsylvanicus terraenovae*. It is even possible that the latter form, which is of questionable distinctness, has been introduced from the mainland, as it is said that schooners of the Labrador summer codfishery often carried home small cargoes of hay to Newfoundland from traditional haying sites in Labrador.—RICHARD H. BACKUS, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.

A TEXAS POPULATION OF THE CRICKET-FROG, *ACRIS*.—A series of *Acris* tadpoles and adults from East Texas provides some additional information.

Collections of tadpoles (322) and adults (Tulane No. 13991) were made from a pool, 26 feet by 8 feet, near Doss, Texas, June 7-8, June 12, June 24, July 7 and August 10, 1948. The tadpole samples include individuals 6 to 17 millimeters in body length (snout-vent). The modes of the June and July samples were all 13 mm., range 6-17 mm.; the mode was 15 mm., range 13-16 mm. in the August sample. The mean size was 11.33 and 12.30 cm. in the June and July samples; the mean increased to 14.46 cm. in the August sample. The frequency distributions of tadpole lengths indicate that the period of egg deposition terminated in early July and that all the tadpoles had attained the size of metamorphosis by August 10. The smallest metamorphosing frog (with some tail stub remaining) was 12 mm. in snout-vent length. Some metamorphosing forms were present in each sample.

A group of 18 recently metamorphosed specimens differs from a sample of 16 small frogs from Caney Lake, Louisiana (Tulane 11443) in having a smooth dorsum and in that the maximum diameter of the eye is  $\frac{1}{4}$  greater than the distance from the eye to

the nostril. The Louisiana specimens have a roughened dorsum and the eye diameter is equal to the distance from the eye to the nostril.

The Texas specimens differ from *Acris gryllus paludicola* Burger, Smith, Smith in that the toe disks are not enlarged; they are not pink in life and the dorsal pattern is distinct. They differ from *Acris gryllus blanchardi* Harper in that they are slender-bodied frogs without extensive webbing of the toes and an extensive dusky area on the posterior surface of the femora.

Although differences are readily discernible in the population, they are not considered sufficient to delineate another subspecies in this complex but are recognized as a local variant of *Acris gryllus crepitans* Baird.—FRED R. CAGLE, *Department of Zoology, Tulane University, New Orleans, Louisiana.*

**RECORD OF COMBAT IN THE SNAPPING TURTLE, *CHELYDRA SERPENTINA*.**—The following notes supplement those of McCauley (1945, Reptiles of Maryland and the District of Columbia). The observations were made by Ruth A. Josephson and Jean L. Burns at the Ringwood Preserve of Cornell University, located near Ellis, 6 miles east of Ithaca, Tompkins County, New York, on August 10, 1952. At 7:30 PM, while on the path skirting the south side of the main pool, a commotion involving splashing and huffing noises was heard. The source was two large snapping turtles which were engaged in combat about 25 to 30 feet from the shore. The turtles apparently showed no fear of the observers, nor did they appear to notice them, and an opportunity was had to watch their behavior closely for 15 minutes.

The center of combat was a cleared space near a hummock in a pool which was otherwise choked with aquatic vegetation, submerged logs and branches, and covered on the surface by floating plants such as *Lemna* and *Wolffia*. The considerable extent of the cleared area indicated that the two turtles may have been engaged in combat for a long period. The depth of water was approximately 8 inches; the bottom was fine silt.

The turtles were about of equal size; approximately 12 inches in plastron length. In combat they faced each other and each attempted by rapid thrusts of the head to grasp the other by the neck. Each defended itself by fending with the front feet, and actual contact by mouth was seldom made. Constantly during the struggle a relatively low puffing noise (not a sharp hiss) was made by each.

Several times one or the other of the combatants would lunge rapidly, the momentum carrying it to a position on top of the other turtle. Then it would slide back to the former position facing its antagonist. Its recovery was aided by the struggles of the snapper in the underneath position.

Occasionally one would make contact by mouth. Then both would either sink slowly under water where much bubbling could be seen and heard, or the one that was bitten would roll on its back, and with this twisting motion seemed to be consistently successful in freeing itself. The period spent under water when so engaged was estimated to be as much as one-half minute. The dark water and the shadow thrown by the covering canopy of trees made it impossible to tell whether fighting continued under water. However, as the two antagonists returned to the surface, they would again join in battle.

After a final brief struggle they parted as they sank slowly, although one could be seen for several moments with the carapace just under the surface. Neither appeared to be a clear cut winner. Neither seemed badly lacerated from bites received, and in general there was little evidence that either was seriously injured and no blood was observed.

Interpretation of this behavior is difficult in view of the lack of information on sex and in view of the late season. The snapping turtle is apparently not common in this particular pond. Ross (1932, A preliminary biological survey of Ringwood Wild Flower Preserve, Cornell Univ. thesis) saw only three specimens during the period 1930-32 when the area was under almost daily surveillance. According to Hamilton (1940, COPEIA (2): 124), in the Ithaca area the snapping turtle mates in May and deposits its eggs in June. Therefore this combat seems not to be associated with territorial fighting in connection with reproduction; perhaps it indicates a tendency for a snapping turtle to defend an area at a time other than the spawning season.—EDWARD C. RANEY AND RUTH A. JOSEPHSON, *Department of Conservation, Cornell University, Ithaca, New York.*

**OBSERVATIONS ON EGG LAYING OF THE TORTOISE *GOPHERUS POLYPHEMUS***—On April 23, 1953, I collected a pair of copulating tortoises from the mouth of a burrow at Estero, Lee County, Florida. This was at 9 o'clock in the morning of a clear, hot day. The burrow, one of many in this section, was in a sandy area with patches of scrub trees and palmettos. The male was mounted on the female, about a foot in from the mouth of the burrow and facing into it. When I removed the male, a fluid was issuing from the vent. I estimated both male and female to be about 25 years old on the basis of their annual growth rings.

Both male and female were taken to my home in Connecticut, where, on June 27, 1953, at 10:50 AM the female started digging a nest in my yard. I suspected she would lay eggs and got my movie camera to record the event. First she swung her body in a circle while digging a shallow bowl-shaped hole with her front feet. This depression was about 2½ feet in diameter. She faced the rim after this

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operation and, using her hind feet only, dug a cylindrical hole slightly flared at the bottom. This hole was about 5 inches in diameter and 5 inches deep, this depth being, apparently, as far as she could reach with her hind feet. She then straddled the hole with her rear feet and, at 11:00 AM, laid her first egg. This was accompanied by the neck being thrust back and forth (in and out of her shell) and by long sighs. As each egg was laid, it was pushed to the front of the hole by a rear foot. Seven eggs were laid, completely covering the bottom of the hole. The brittle egg shells, when pushed into position in the hole, grated together as if they were made of etched glass. The last egg was laid at 11:30 AM. The tortoise then scraped a cover of dirt from the sides of the hole with her rear feet and lightly covered the eggs. Now the front feet, moved for the first time since the hind ones were brought into operation, were employed to bring dirt to the rear to complete the covering. She was very unsteady and swayed as if the egg laying had exhausted her. Covering the nest took 20 minutes. After the nest was covered, the female walked back and forth over the nest area and brushed it lightly with the nails of her front feet. The entire procedure from the first digging through the final brushing of the nest took one hour.

According to Carr (1952, Handbook of Turtles: 338) the gopher tortoise has never been observed copulating, digging a nest or laying eggs. The egg laying is now recorded on 40 feet of colored movies which I took of the event.—JAMES H. KENEFFICK, 19 Leander Street, Danielson, Connecticut.

**NOTES ON THE LIZARD *EUMECES EGREGIUS* IN GEORGIA.**—The only Georgia records of *Eumeces egregius* (Baird) that this author has been able to find in the literature are from Charlton (Taylor, 1935, Univ. Kansas Sci. Bull., 23: 496) and Richmond (Neill, 1940, COPEIA, (4): 266) counties. Charlton County is situated at the Georgia-Florida border, and Richmond County is situated at the Georgia-South Carolina border. The distance between these two areas is about 200 miles. On September 7, 1952, one *E. egregius* was collected by the author in Toombs County, at the junction of U. S. Route No. 1 and the Altamaha River. This area is about midway between the other two counties. Quite probably future collecting will demonstrate that this animal occurs throughout the coastal plains region of Georgia, and some distance westward.

The immediate vicinity of the capture was open, sandy, and dry. The only other reptile that seemed to be active was *Cnemidophorus sexlineatus*. Neill (*loc. cit.*) also reported *E. egregius* from a dry, open area. The specimen reported on here was seen running slowly across U. S. Route No. 1, and, when

approached, ran into a small clump of grass. It was found coiled up, the head in the middle, the conspicuous red tail surrounding the rest of the body. Exposed, it remained motionless.—HARVEY S. JANSON, Museum of Natural History, University of Kansas, Lawrence, Kansas.

**LONGEVITY OF SNAKES IN CAPTIVITY IN THE UNITED STATES AS OF JANUARY 1, 1954.**—This list contains what records are available to us. We would like to hear from anyone having better records, or ten-year records of other species. We intend to bring the list up to date each year as of the first of January. Only the oldest snake of each species or subspecies is listed. Age is given in years (second column) and months (third column), and the source of the record is included (fourth column). An asterisk indicates that the specimen was alive on January 1, 1954. Symbols used are as follows: AM = American Museum of Natural History, BdZ = Brookfield Zoo, BxZ = Bronx Zoo, GOW = Grace O. Wiley, GPM = George P. Meade, JGM = John G. Moore, NCM = North Carolina State Museum, PZ = Philadelphia Zoo, RMS = R. M. Stabler, SDZ = San Diego Zoo, SIZ = Staten Island Zoo, SLZ = St. Louis Zoo, TC = Tabor College, WZ = Washington Zoo.

<i>Ancistrodon conortrix laticinctus</i> *	13	7	SDZ
<i>Ancistrodon conortrix mohensis</i> *	17	6	SDZ
<i>Ancistrodon piscinor</i> *	18	8	RMS
<i>Boa constrictor constrictor</i>	12	3	PZ
<i>Boa constrictor imperator</i> *	16	3	SDZ
<i>Boiga dendrophila</i>	11	9	SLZ
<i>Corallus annulatus</i>	12	4	PZ
<i>Corallus enydris cooki</i>	14	3	SDZ
<i>Crotalus adamanteus</i>	14	9	NCM
<i>Crotalus atrox</i> *	17	7	SDZ
<i>Crotalus basiliscus basiliscus</i>	10	1	SDZ
<i>Crotalus cerastes laterorepens</i> *	11	8	SDZ
<i>Crotalus durissus durissus</i>	12	0	SLZ
<i>Crotalus horridus horridus</i>	15	7	SDZ
<i>Crotalus mitchelli pyrrhus</i>	11	9	SDZ
<i>Crotalus ruber ruber</i> *	12	4	SDZ
<i>Crotalus tortugensis</i> *	16	9	SDZ
<i>Crotalus unicolor</i> *	13	5	SDZ
<i>Crotalus viridis helleri</i> *	16	10	SDZ
<i>Crotalus viridis viridis</i> *	15	1	SDZ
<i>Dendroaspis viridis</i>	11	3	SLZ
<i>Drymarchon corais couperi</i> *	21	4	JGM
<i>Elaphe guttata guttata</i>	21	9	PZ
<i>Elaphe obsoleta obsoleta</i>	16	0	AM
<i>Elaphe obsoleta quadrivittata</i> *	16	7	SDZ
<i>Elaphe obsoleta spiloides</i> *	12	5	RMS
<i>Epicrates angulifer</i> *	15	2	SDZ
<i>Epicrates cenchria crassus</i>	14	6	SIZ
<i>Epicrates cenchria maurus</i>	27	4	BxZ
<i>Epicrates striatus</i>	16	0	PZ
<i>Eunectes barbouri</i>	13	11	PZ
<i>Eunectes deschauensei</i>	13	10	PZ
<i>Eunectes murina</i>	28	0	WZ
<i>Helicops schistosus</i>	12	3	PZ
<i>Hemachatus haemachatus</i>	11	9	BdZ
<i>Lampropeltis dolia amaura</i> *	17	7	GPM

<i>Lampropeltis dolia annulata*</i>	13	5	SDZ
<i>Lampropeltis getulus brooki</i>	10	0	SDZ
<i>Lampropeltis getulus californiae</i>	14	10	SDZ
<i>Lampropeltis getulus floridana*</i>	10	6	SDZ
<i>Lampropeltis getulus holbrooki*</i>	10	8	SDZ
<i>Lampropeltis zonata multifasciata</i>	13	6	SDZ
<i>Lichanura roseofusca roseofusca</i>	12	0	SDZ
<i>Loxocemus bicolor*</i>	11	0	PZ
<i>Masticophis flagellum piceus</i> (black)	11	2	SDZ
<i>Masticophis flagellum piceus</i> (red)	12	2	SDZ
<i>Masticophis flagellum testaceus</i>	13	5	SDZ
<i>Naja melanoleuca*</i>	25	3	SDZ
<i>Naja naja</i>	12	4	PZ
<i>Naja naja atra</i>	10	3	BdZ
<i>Naja nigricollis*</i>	19	2	BdZ
<i>Naja nivea</i>	15	3	SDZ
<i>Ophiophagus hannah</i>	11	10	GOW

<i>Pituophis catenifer affinis</i>	13	4	SDZ
<i>Pituophis catenifer annectens</i>	15	2	SDZ
<i>Pituophis catenifer catenifer</i>	11	0	SDZ
<i>Pituophis melanoleucus melanoleucus*</i>	13	5	SDZ
<i>Python curtus curtus*</i>	17	10	SDZ
<i>Python molurus bivittatus*</i>	17	7	SDZ
<i>Python molurus molurus</i>	13	0	PZ
<i>Python reticulatus</i>	20	0	SLZ
<i>Python sebae*</i>	47	1	PZ
<i>Rhinocheilus lecontei lecontei</i>	12	1	SDZ
<i>Sistrurus catenatus</i>	14	0	TC
<i>Ungaliophis continentalis</i>	17	8	GOW

—C. B. PERKINS, *Zoological Society of San Diego, San Diego, California.*

## Ichthyological Notes

**THE SOUTHERN LIMIT OF THE GARFISHES, FAMILY LEPISOSTEIDAE.**—The majority of the living species of gars, genus *Lepisosteus*, are confined to eastern North America, where they range from southeastern Canada southward to the basin of the Río Usumacinta, along the México-Guatemala boundary, and to Cuba.

In his stimulating review of the zoogeography of cold-blooded vertebrates, Darlington (1948, Quart. Rev. Biol., 23: 11) repeated the erroneous but well established statement that gars range southward to Panamá. Even in the classical work by Regan (1906-08, Biología Centrali-Americana, 8: 182), Panamá is listed without comment. More recently, Clark (1952, Ann. Rept. Smith. Inst., 1951: 297) has also perpetuated the slip. The precise way in which this error originated is unimportant; that it got into two of the most widely used reference works on American fishes is indeed unfortunate, for such misstatements are most difficult to eradicate.

The southernmost representative of the gars generally has been referred to *Lepisosteus tropicus*, which was described by Gill (1863, Proc. Acad. Nat. Sci. Phila., 1863-64: 172-3) on the basis of a single specimen collected by Capt. Dow from the "Western Coast of Central America" (as indicated in the title of the paper). The type locality was restated by Jordan and Evermann (1896, U. S. Nat. Mus., Bull. 47: 111), and repeated by Jordan, Evermann and Clark (1930, Rept. U. S. Comm. Fish., 1928 (2): 38), as "streams near Panama." This was modified to "Panama" by subsequent authors. That gars do not occur in that republic has been demonstrated conclusively by the field work of Meek and Hildebrand and others (see Hildebrand, 1938, Field Mus. Nat. Hist., Zool. Ser., 22 (4): 217-359). Moreover, there is no evidence in the catalogue book at

the U. S. National Museum or in the jar containing the type specimen of *L. tropicus* (USNM No. 6806) to indicate that the species was taken in or near Panamá. The type jar does contain a handwritten label reading "Costa Rica Dow," but this locality is questionable (see below).

No mention of type localities was made by Gill for any of the numerous species he described in the paper referred to above. In the *Check List*, Jordan, Evermann and Clark modified "western coast of Central America" to "Panama" or to "Cape San Lucas" for the type localities of some of Gill's species. This action was apparently based, in part at least, on definite locality data in the National Museum register. It is clear that the material collected by Dow represents species taken from several localities along the Pacific slope of Middle America, from Panamá apparently to as far north as Cabo San Lucas, Baja California.

It cannot be stated unequivocally that *Lepisosteus* does not occur in Costa Rica. However, the fish fauna of that republic has been collected and studied fairly well, particularly along the Pacific coastal plain where gars might be expected to occur. The papers by Regan (1908, Ann. Mag. Nat. Hist., ser. 8, vol. 2: 455-64), Fowler (1917, COPEIA, No. 39: 2-4), Hildebrand (1930, COPEIA (1): 1-9), and Alfaro (1935, Investigaciones Científicas. Editorial Trejos Hermanos, San Juan, Costa Rica; fishes, pp. 117-42) do not mention gars. I consider this to be particularly significant in the latter publication for Dr. Alfaro, accomplished naturalist of the National Museum of Costa Rica, would scarcely be expected to overlook such an unusual fish, and one which is also of importance as food. Also, Donald S. Erdman (formerly with the U. S. National Museum) wrote me in July, 1953, that during nearly two years

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of commercial fishing and observation along the Pacific coast of Costa Rica, he never saw *Lepisosteus*. He went by boat up the Río Tempisque, which probably affords the most likely habitat for gars in Costa Rica, and also the Río Jesús María (east of Puntarenas), but neither saw nor caught *Lepisosteus*. Moreover, Dr. E. R. Dunn has told me that in his researches on Neotropical herpetology he has found no evidence to indicate that Captain Dow visited Costa Rica. Furthermore, Dr. Dunn says that most of the Panamá herpiles credited to Dow actually came from La Unión, El Salvador, a known center of Dow's collecting activities (see Jordan and Gilbert, 1882, Proc. U. S. Nat. Mus., 5 (1883): 373-7).

There are no large rivers on the Pacific slope between the Nicaraguan shore of the Gulf of Fonseca and the Gulf of Nicoya, Costa Rica, and it seems most unlikely that *Lepisosteus* would occur in this area. The region is, however, poorly known ichthyologically. Gars definitely inhabit waters of the Pacific slope of Middle America from Chiapas (and likely from southeastern Oaxaca), México, south-eastward to the boundary between Guatemala and El Salvador (Lindner, 1947, Trans. Amer. Fish. Soc., 74 (1944): 76; Regan, 1906-08: 182; and personal observations in Guatemala). The absence of *Lepisosteus* from the list of fishes reported from El Salvador by Hildebrand (1925, Bull. U. S. Bur. Fish., 41: 237-87) may reflect the fact that the field work was done largely in fresh waters. Perhaps for the same reason, gars were not reported from the Pacific drainage of Honduras (Carr and Giovannoli, 1950, Occ. Pap. Mus. Zool. Univ. Mich., 523: 1-38). However, Dr. Carr has written me that he was told by the local gente that gars do occur along the Gulf of Fonseca in the brackish river mouths. In Guatemala, *Lepisosteus* is confined to brackish-water estuaries and coastal waterways, in particular the Chiquimulilla Canal, where tidal variation is small (the tide varies from 7 to 11 feet in the Gulf of Nicoya at Puntarenas). The fishes of such habitats in El Salvador and Honduras are not well known to ichthyologists.

There is another reason for regarding as likely the occurrence of the gar in El Salvador and Honduras. What is taken to be the same species also inhabits Lake Managua and Lake Nicaragua but is otherwise unknown from the Atlantic slope of Middle America between these lakes and the Río Usumacinta. During field work in Guatemala, in 1946 and 1947, we especially sought this fish in what appeared to be suitable habitats on the Atlantic slope, but failed to secure specimens. Moreover, the native fishermen of that area know the gar well, and repeatedly told me that it occurs only to the north in El Petén (Río Usumacinta basin), where Carl L. Hubbs took many specimens in 1935. Although the

Atlantic coastal waterways of Honduras and particularly Nicaragua have been scarcely explored for fishes, it appears to me that the gar of the Great Lakes of Nicaragua gained access to those basins from the west, when Lake Nicaragua was a gulf with an outlet to the Pacific (Durham, 1944, Science, 100: 49). Consequently, I do not anticipate that *Lepisosteus* will be found elsewhere on the Atlantic slope of Nicaragua or in northern Honduras. This note is not concerned with the taxonomic status of the southernmost representative (or representatives) of *Lepisosteus*, considered by Holly (1936, in: Das Tierreich. Pisces, 4, Ganoidei, p. 53) to be a subspecies of *L. trisotichus*. Until careful systematic studies are made and published, it is best to continue to refer the populations from the Pacific slope and from Nicaragua to *Lepisosteus tropicus*. The gar of the Usumacinta basin has been so classified (Evermann and Goldsborough, 1902, Bull. U. S. Fish Comm., 21 (1901): 139). The verified range of *L. tropicus* includes (in addition to the Río Usumacinta) the region from the Pacific drainage of Chiapas, México, to the Guatemala-El Salvador border and the Great Lakes of Nicaragua. It may occur also north to the Isthmus of Tehuantepec (in southeastern Oaxaca) and probably inhabits El Salvador and southern Honduras (including the adjoining tip of Nicaragua). Statements of its presence in Panamá are in error, and there is no evidence that it lives in the streams along the Pacific Coastal Plain of Costa Rica or in those of the western slope of Nicaragua.

The following information was received after this manuscript was in press. In a letter dated April 13, 1954, Dr. J. M. Orozco C., Jefe Sección de Botánica, Universidad de Costa Rica, reported definite records of garfish in Costa Rica only from tributaries to Lake Nicaragua. In response to my request for information on the distribution of *Lepisosteus* in Costa Rica and neighboring areas, he wrote that gars are abundant in Río Sapoa, Río Frío, Río Zapote, Río Guacalito, Río Niño, Río Papalón and other streams of northern Costa Rica that drain into Lake Nicaragua. For Nicaragua his information indicated that *Lepisosteus* inhabits the Río Negro (south of Choluteca, Honduras), a tributary to the Gulf of Fonseca, as well as Lake Managua and Lake Nicaragua. Answers to his inquiries regarding the possible occurrence of a gar on the Pacific slope of Costa Rica had not been received when Dr. Orozco wrote, but I feel confident that no *Lepisosteus* inhabits this area.—ROBERT RUSH MILLER, Museum of Zoology, University of Michigan, Ann Arbor, Michigan.

**OCCURRENCE OF AN APPARENT HYBRID MACKEREL (*SCOMBEROMORUS*) OFF MIAMI, FLORIDA.**—While examining fishermen's

catches from the Gulf Stream area at Pier 5, Miami, Florida, on March 17, 1953, I came across a 3-pound, 621-mm. fish which appeared to be intermediate in certain characters between the king mackerel, *Scomberomorus cavalla* (Cuvier), and the Spanish mackerel, *Scomberomorus maculatus* (Mitchill). Listed below are the characters which separate the two species and those of the specimen in question:

<i>Scomberomorus cavalla</i>	Aberrant specimen	<i>Scomberomorus maculatus</i>
7-8 gillrakers	9 gillrakers	10-11 gillrakers
Lateral line curving abruptly downward below second dorsal	Intermediate in slope	Lateral line not curving abruptly downward below second dorsal
First dorsal not black anteriorly	Moderate pigmentation but not black	First dorsal black anteriorly
Sides of body with no spots	Sides of body with faint, but recognizable, spots	Sides of body with distinct spots

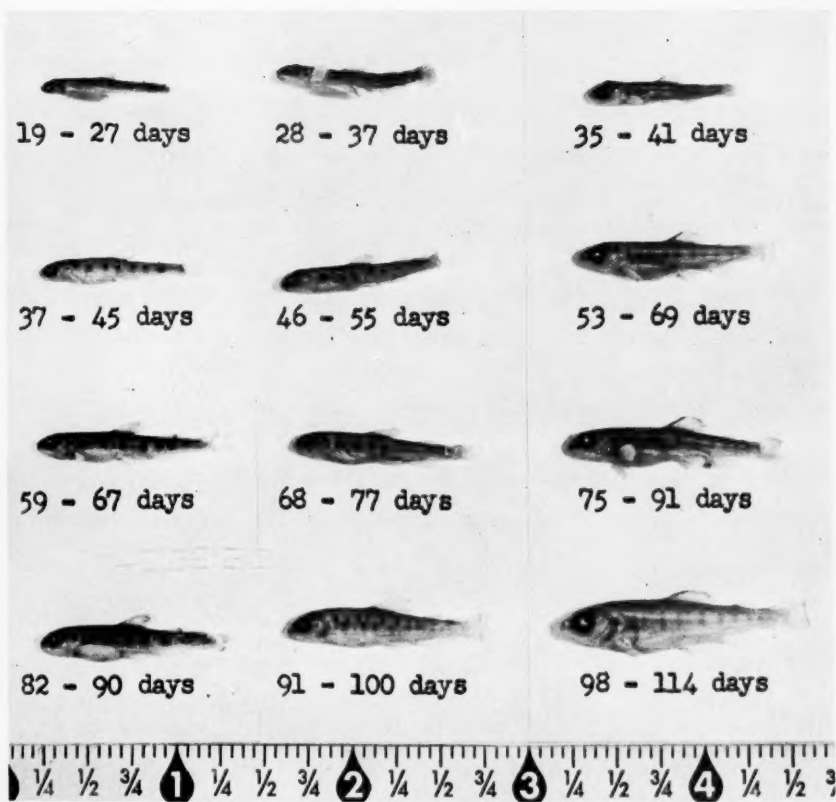
In examining 600 to 700 specimens of the Spanish and king mackerels, I have found that the gillraker count remains constant, never deviating from the figures listed above. The individual with 9 gillrakers and other definitely intermediate characters may be a hybrid.

The specimen is immature and possibly a female, but the gonads are so poorly developed that accurate diagnosis of sex was impossible. *S. cavalla* and *S. maculatus* are both known to spawn during March, and I have found that a fish 621 mm. long would normally be spawning at that time. Therefore it is believed that this specimen is an infertile hybrid. Furthermore, while *S. cavalla* normally occupies water closer to the edge of the Gulf Stream, and *S. maculatus* is more of an inshore fish, the two may be caught in the same locality during the spring months, which would provide the opportunity for hybridization to occur. The hybrid is deposited in the collection of the University of Miami Department of Zoology.—DONALD DE SYLVA, *The Marine Laboratory, University of Miami, Coral Gables 34, Florida.*

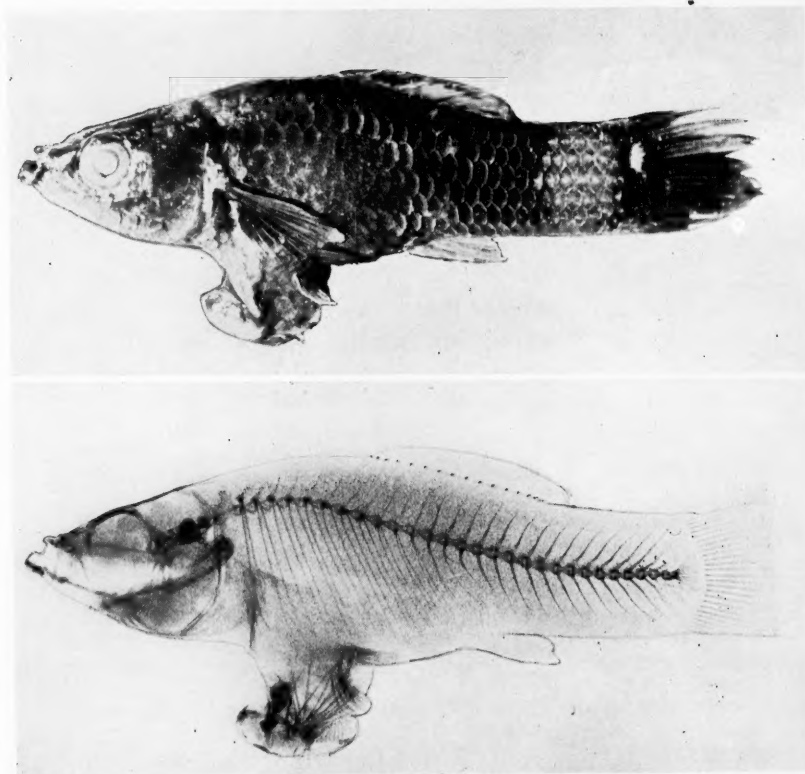
**FIELD CHARACTERS OF PROLARVAE AND ALEVINS OF BROOK, BROWN AND RAINBOW TROUT IN MICHIGAN.**—This note was prepared primarily for those fishery biologists who are assigned to biological surveys of waters containing brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), and rainbow trout (*Salmo gairdneri*). Field identification of the early life-history stages of these salmonids is facilitated by diagnostic differences in pigmentation (Pl. I). Among prolarvae and alevins, up to 1½ inches long, only the rainbow trout has the front margin of the

dorsal fin strongly pigmented and only the brook trout has conspicuous pigment on the adipose fin. The large, pear-shaped, parr marks of the brook trout are generally distinctive, but they vary too much in shape and number to provide a completely reliable means of distinguishing this species. The surface of the abdomen is speckled in the brown trout and immaculate in the other two species, whereas the chin (ventral surface of the lower jaw) is speckled in the brown and rainbow trouts but clear in the brook trout. The photograph indicates other differences (such as the larger size of the pectoral fins in the brown trout) but these do not lend themselves as readily to quick field identification. The fish illustrated were obtained from the Wolf Lake Hatchery at Mattawan, Michigan, during the spring of 1952; and therefore the ages of the fish were known. Since all fertile eggs from any one female trout do not hatch simultaneously, the range in ages takes into account the first and last hatching date for each lot of fish. Much difficulty was experienced in photographing the preserved fish as they tended to curl badly on drying. Mr. William Cristanelli, photographer for the Institute for Fisheries Research, is to be commended for obtaining such a fine photograph under these conditions.—EDWARD H. BACON, *Pigeon River Trout Research Station, Michigan Department of Conservation, Vanderbilt, Michigan.*

**SPAWNING OF AMERICAN SMELT, *OSMERUS MORDAX*, IN CRYSTAL LAKE, BENZIE COUNTY, MICHIGAN.**—So far as is known or reported, smelt spawn only in streams. While observing the spawning activities of the Crystal Lake smelt, I noted what appeared to be spawning in the lake proper. On the south shore in the vicinity of the outlet dam, smelt were found on the evening of April 6, 1953, distributed along the shoreline over a gravel bottom, probably spawning. The activities of the smelt fishermen may have been a factor in this unusual behavior. Dipping of smelt is allowed in the outlet of Crystal Lake during the annual spawning run where there is a downstream migration only, and also, with limitations, in the inlet creeks. As the law permits dipping the outlet stream without defining the origin of the outlet, dippers can work the short stream-like section ahead of the dam. The fishermen invariably carry lights with them while dip-netting and, as the smelt are obviously negatively phototropic, these lights deter movement of the fish from the lake down the outlet. Although the regulation on dipping at the outlet has been the same for several years, this year was the first time the smelt were observed or reported to come into the gravel shore area of the lake. The heaviest concentrations of smelt occurred within approximately 1000 yards west of the outlet, with



Early life history stages of brook (left), brown (center) and rainbow (right) trout.



Photograph (upper) and X-radiograph (lower) of abnormal *Mollenesia latipinna*, 41.7 mm. in standard length, to show tail structure and elements of pectoral and pelvic fins. The radiograph was made on a non-screen film, using a Picker Diffraction Unit, at 35-40 K.M., 10 MA, exposed for 30 seconds at a distance of 6 inches.

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fewer fish in the shoreline shallows at three check spots on the south shore as far as three miles west of the dam. The areas where fewer smelt were seen had less dense gravel deposits.

A picture taken from dry land shows smelt in positions of actively spawning fish and also illustrates the gravel-stone habitat. (This photograph is available from the writer.)

The smelt were coming in as close to the shore as they could, especially in the areas dominated by gravel. While standing in the dark without a light, much splashing activity could be heard, and this was presumed to indicate active spawning. Whenever a light was cast on the water, smelt dispersed quickly, some even onto the sand beach. Upon investigating some of the rocks and stones for eggs on the evening of April 6, 1953, a few live eggs were found. As the writer was interested in finding a good method for collecting smelt eggs, fourteen hatchery trout egg trays made of common household screen with 12" x 16" x 3/4" wood frames, painted black, were secured for an experiment. These trays were anchored to the bottom at a depth of about 12 inches in the spawning area. Unfortunately, so much rock and gravel had to be placed on the screens to anchor them that there was little exposed screening. On the evenings of April 7 and 8, these screens had eggs on the anchor gravel, screen, and wood frames. A visit to the lake was made a week later to pick up the screens, but someone had removed them. Investigation of the rocks and stones again showed live eggs on most stones, but no dense mat of eggs on any one stone. A few dead eggs were noted.

The Crystal Lake smelt run has varied in its intensity in the past years. The 1953 run was reported to be a heavy rise from a reported low three years before. It is possible that the density of the population was a factor in the shoreline spawning of the species.

I have had consistent reports that smelt spawn annually in Lake Michigan along the shores of Northport Bay in the vicinity of Northport Village, Leelanau County, Michigan. On April 10, 1953, which was the day following the first reported run at Northport, numerous rocks and stones in the spawning area were examined for eggs. A few live eggs were found attached to stones in arm-length depths. On the evening of April 11, an attempt was made to seine a number of smelt to be used for experimental purposes. Unfortunately, interference by commercial fishermen created an abnormal situation. Just before the run had started, the commercial fishermen set more than 500 feet of gillnets parallel to the shore at a depth of about 4 feet. At dark the gillnets were observed to "fill" rapidly but only about 100 smelt could be seined with a 75-foot bag seine in the area between the gillnet sets and shore. The nets were lifted after about three hours,

and were found to be weighted with smelt. Observations with a light, after the nets were cleared, failed to show any concentrations of smelt. It was obvious that the run was over and no further attempts were made to seine. A cursory check of our sample showed the female smelt to be mostly green, with a few in ripe condition and the males mostly nearly ripe.—STANLEY J. LIEVENSE. *Michigan Department of Conservation, Traverse City, Michigan.*

**AN UNUSUAL CONDITION IN THE TROPICAL FISH *MOLLIENESIA LATIPINNA*.**—On March 6, 1951, a live female of *Mollienesia latipinna* LeSueur, 41.7 mm. in standard length, was brought to the attention of the senior author by one of the local aquarium dealers. This specimen was so greatly distended as to give the appearance of a rupture resulting from a swollen fertile condition of tumorous growth. However, two days later 16 normal black young were born and some of the swelling receded. These young lived until April 30, 1951, feeding and growing normally. The adult fish continued to live, never preying on the young, until May 1, 1951, when for a week it simply sulked on the bottom of the aquarium and died on May 7, 1951. It was then observed that death was due to a fungal disease that had spread upwards from just anterior to the swollen area to cover the gills.

After the birth of the 16 young, a bulge still persisted on the adult. On close observation it was seen to consist of a tail structure, protruding to the right, and two pectoral and pelvic fins (Pl. I). No anal or head regions were evident. While alive, the tail structure was often seen to vibrate. None of the other fins exhibited this behavior.

It was tentatively concluded that this fish was one of two which had matured after incomplete embryonic cleavage. This supposition was further strengthened when X-ray photographs were taken on May 15, 1951, at 30 seconds, 10 M.A., 35–40 K.V. on a non-screen film with a cardboard holder. The pictures were obtained with a Picker Diffraction Unit through the aid of Mr. C. Henry of the Mechanical Engineering Department, University of Pittsburgh. They show (Pl. I) a complete and normal vertebral skeleton for the adult fish. The swollen area contains ribs and two large masses of incorrectly fused vertebral elements, but the tail portion shows no normal vertebral elements. However, after photographs and serial sections stained with iron hematoxylin were made by the junior author, two notochordal areas were observed, one of which extended into the tail structure. No internal organs were noticed in the swollen area.

This condition is well known in freshwater hatchery fishes and can be easily produced by sudden radiation shocks. Innes in his *Exotic Aquarium Fishes* (1946, Ed. 7: 467) cited a single hybrid guppy

× mollienias as possessing a slight swollen area under the gill plates but did not mention that such a condition has ever been observed for this species.—F. J. SCHWARTZ AND C. B. CURTIN, *Pymatuning Laboratory of Field Biology, Department of Biological Sciences, University of Pittsburgh, Pittsburgh 13, Pennsylvania.*

AN ERRONEOUS RECORD OF THE CALIFORNIA KILLIFISH, *FUNDULUS PARVIPINNIS*, FROM CABO SAN LUCAS, BAJA CALIFORNIA<sup>1</sup>.—For the nine reasons here detailed, we regard as erroneous the record of the California killifish, *Fundulus parvipinnis* Girard, from Cabo San Lucas at the tip of Baja California, just within the tropics. The record was introduced by Jordan and Gilbert (1882, Proc. U. S. Nat. Mus., 5 (1883): 355) in their list of species recorded in the United States National Museum as having been collected by John Xántus (János Xántus) at Cape San Lucas.

(1) As Jordan and Gilbert pointed out, there had been considerable confusion regarding this collection. The specimens had become scattered and many had been lost or destroyed. The Xántus material was entered in the National Museum catalog at several different times and places. For some of the lots, no original entry was made for locality or for species. The original entry for the specimens in question gave only the locality (Cape San Lucas). Subsequently, in handwriting believed to be that of David Starr Jordan, the name of the species and the collector (Xántus) were added, and under the column headed "Remarks", "(Jordan)" was entered. (We thank E. A. Lachner for this information.) Although there is no good reason to doubt that Xántus collected nearly all of the material accredited to him, doubts have arisen regarding the provenance of specimens from different regions, for example Cabo San Lucas and Colima. Most of the material was probably rightly attributed to Cape San Lucas, but some came from other regions, even from the Atlantic Coast.

(2) The three other species of cyprinodonts reported by Jordan and Gilbert as having been collected by Xántus from the same locality almost certainly came from elsewhere. Thus, the type material of *Ilyodon furcoides*, a goodeid, was very probably collected by Xántus in the state of Colima on the Mexican mainland (Hubbs and Turner, 1939, Misc. Publ. Mus. Zool. Univ. Mich., No. 42: 59), where Xántus operated in 1863 (Kellogg, 1932, U. S. Nat. Mus., Bull. 160: 7; Madden, 1949, Xántus, Hungarian Naturalist in the Pioneer West. Books of the West, Palo Alto [Calif.]: 172–4). The types of *Fundulus vincenti* and *F. extensus* were apparently based on specimens of the common Atlantic Coast

species, *F. heteroclitus* (Linnaeus) and *F. diaphanus* (LeSueur), respectively, that had somehow become mixed with the Xántus collection (Hubbs, 1931, Occ. Pap. Mus. Zool. Univ. Mich., No. 231: 2–3). "The false ascription is probably not attributable to Xántus" (Madden, 1949: 275).

(3) No cyprinodonts were reported by Gill (1862–63, Proc. Acad. Nat. Sci. Phila., 1862: 140–51, 242–6, 249–62; 1863: 80–8; and a few subsequent papers) in his descriptions of the extensive material sent to the Smithsonian Institution from Cabo San Lucas. While he was preparing his catalogue of the fishes obtained by Xántus at this locality, Gill was in contact with the collector (Madden, 1949: 162).

(4) There appears to be no suitable habitat for *Fundulus* at Cabo San Lucas (Hubbs has observed the entire shoreline of southern Baja California from the air). Locality records of a century ago, however, were loose, and the small lagoon at the mouth of Río San José, at San José del Cabo, which Xántus visited, might have harbored native cyprinodonts. But none was obtained here among the fishes collected by Gustav Eisen (Rutter, 1896, Proc. Calif. Acad. Sci., ser. 2, Vol. 6: 263–6) or by the ALBATROSS (Osborn and Nichols, 1916, Bull. Amer. Mus. Nat. Hist., 25: 158, 164–5, 175, 180). Nor have any been included in the recent unreported collections known to us to have been made in Río San José or its mouth. All the cyprinodonts obtained recently in that stream are referable to *Gambusia affinis affinis* (Baird and Girard), which was introduced here for mosquito control by Percy S. Barnhart on April 26, 1931 (data from Barnhart's diary, in Scripps Institution of Oceanography).

(5) The Cape fauna is almost strictly tropical, whereas *Fundulus* is essentially a temperate genus. This argument is weakened by the fact that the genus occurs in the probably equally warm waters around the peninsula of Yucatán. The Yucatán species, however, may be regarded as a spillover from the abundant *Fundulus* fauna of eastern North America.

(6) The specimens in question (USNM No. 7242), 6 mature males and 3 mature females, kindly loaned by Leonard P. Schultz, differ in several diagnostic characters from the subspecies, *Fundulus parvipinnis brevis*, described by Osborn and Nichols from Magdalena Bay, Baja California (the southernmost verified outpost of the species and of the genus on the Pacific Coast). And, as noted by Jordan and Gilbert (1882: 355), they are the counterparts of breeding adults of *F. p. parvipinnis* from San Diego Bay, California (the type locality of the species). They agree in the relatively large size of the adults (males 38–52 mm. in standard length, females 53–60 mm. long), in the sooty color of the breeding males, and in the marked elongation of the males' anal rays (longest ray about 2.7–2.9 in standard

<sup>1</sup> Contributions from the Museum of Zoology, University of Michigan, and from the Scripps Institution of Oceanography, New Series, No. 705.

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TABLE I

NUMBER OF LATERAL SCALES AND VERTEBRAE IN TWO SPECIES OF *Fundulus parvipinnis*

Subspecies	Lateral scales							No.	Ave.
	31	32	33	34	35	36	37		
<i>F. p. parvipinnis</i>									
Carpinteria to									
Ensenada*	..	..	5	64	184	28	2	283	34.9
San Diego									
Bay†	..	..	..	19	23	..	..	42	34.5
"Cape San									
Lucas"	..	..	..	4	5	..	..	9	34.5
<i>F. p. brevis</i>									
Magdalena									
Bay‡	2	23	23	1	..	..	..	49	32.5
Subspecies	Vertebrae							No.	Ave.
	32	33	34	35	36	37			
<i>F. p. parvipinnis</i>									
Escondido Cr.									
to Ensenada*	..	..	..	7	12	1	20	35.7	
San Diego Bay	..	..	..	1	9	..	10	35.9	
"Cape San									
Lucas"	..	..	1	2	6	..	9	35.5	
<i>F. p. brevis</i>									
Magdalena									
Bay‡	1	1	8	..	..	..	10	33.7	

\* Exclusive of San Diego Bay.

† Including a cotype, USNM No. 938.

‡ Including holotype, USNM No. 87542 (formerly Amer. Mus. Nat. Hist. 5208), 9 paratypes and 39 topotypes (USNM 12353, UMMZ 157687).

length). They also agree in the high number of lateral-line scales and of vertebrae (Table I). The scale count (from upper end of gill opening to caudal base) is questionable in about half of the specimens, since many scales have been rubbed off. But the minimal rather than maximal number is recorded, and the increased number (compared with that in *F. p. brevis*) is supported by the vertebral counts (taken from X-ray photographs, the urostyle included). The Xántus specimens further agree with topotypes of *F. p. parvipinnis* in the slender body and small head: the greatest body depth enters the standard length approximately 3.7 to 4.1 times; the length of the head enters this length about 3.25 to 3.55 times (we give only approximate measurements, since the specimens are soft and flabby, but we have used care to avoid subjective errors). These data are in close agreement with measurements given by Osburn and Nichols (1916: 151) for San Diego material, and contrast with their data for *F. p. brevis* (body depth, 3.1 to 3.6, and head length, 3.0 to 3.3, in the standard length). The reduced number of vertebrae and scales and the large head and the robust body of *F. p. brevis* are characters that one would expect

to find in the southernmost populations of the species.

(7) When Xántus made his collections, from 1857 to 1864 (Madden, 1949), there was a northward shift of the fish fauna in southern California (Hubbs, 1949, Jour. Marine Res., 7 (1948): 459-82) and very probably also in Baja California—minimizing the chance that a temperate species occurred then within the tropics.

(8) Xántus could well have secured the specimens in southern California. He was at San Pedro in April or May, 1857 (Madden, 1949: 55), and was probably in contact with Dr. George Hammond who collected about San Diego (Madden, 1949: 73-4). He shipped a keg of alcoholic specimens to Washington in November, 1857 (Madden, 1949: 89). He may have bought the specimens (he often made such purchases) and then may have mislabeled them as from Lower California, as he is known to have done for a number of birds (Madden, 1949: 129-30), or he may have left them unlabeled. Or, these fish may have become mixed through curatorial mishandling with the Xántus collection from the Cape.

(9) Lastly, it is noteworthy that the erratic Hungarian who is recorded as the collector of *Fundulus parvipinnis* at Cabo San Lucas has been proved in a recent critical biography (Madden, 1949) to have been rather deficient in the virtues of reliability and veracity.—ROBERT RUSH MILLER AND CARL L. HUBBS, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan, and Scripps Institution of Oceanography, University of California, La Jolla, California.*

STATUS OF THE BRONZE DARTER, *HADROPTERUS PALMARIS*.—In 1941, Reeve M. Bailey described the bronze darter, *Hadropterus palmaris*, a percid fish from the Coosa-Alabama River system of Alabama and Georgia (Jour. Wash. Acad. Sci., 30 (12): 524-30). The description was based on 33 specimens from three localities, of which two were in southeastern Alabama (27 specimens) and the other locality was in northwestern Georgia (6 specimens). Since *Hadropterus palmaris* is apparently confined to the Coosa-Alabama drainage, these collections sampled the extremes of its range. Counts of the number of scales in the lateral line and the number of pectoral rays (Table I) were selected for presentation here as it was felt that they would reflect little if any difference between methods of counting by two independent workers. These were also the best indicators of variation of many characters treated by the author in his recent work on *Hadropterus nigrofasciatus* (Crawford, 1953, Ph.D. Thesis, Cornell University: 93-108).

If Ginsburg's method (1938, Zoologica, 23 (3):

TABLE I

SCALE ROWS ALONG LATERAL LINE AND PECTORAL RAY COUNTS  
(BOTH FINS) IN *Hadropterus palmaris*  
After Bailey (1941: 527) and Crawford (1953)

Scale rows	Source of data and locality				
	Bailey, 1941		Crawford, 1953		Bailey plus Crawford
	Georgia	Alabama	Georgia	Alabama	
57	..	..	1	..	1
58	..	..	..	..	..
59	2	1	5	..	8
60	..	5	3	1	9
61	1	2	4	..	7
62	..	2	3	..	5
63	3	1	2	..	6
64	..	5	3	..	8
65	..	2	1	1	4
66	..	3	5	3	11
67	..	1	1	..	2
68	..	1	3	1	5
69	..	2	1	1	4
70	..	1	..	..	1
71	..	..	..	..	..
72	..	..	..	..	..
73	..	1	1	..	2
Pectoral rays					
12	..	..	6	..	6
13	..	16	9	4	29
14	3	36	44	4	87
15	9	2	3	4	18

255-9) of separating populations arithmetically is applied to Bailey's data, Table I, and a line is drawn between 63 and 64, an average divergence of 79.7% is noted. For the number of pectoral rays, the best line of separation is between 14 and 15, and the average divergence is 81.5%. These figures conform to Ginsburg's definition that a valid subspecies should be 80% separable on the main differentiating character, and suggest the possibility of a subspecies of *Hadropterus palmaris* at either end of the river system. It is also notable that the Georgia fishes, which are from a higher latitude than are those from Alabama, possess fewer scales in the lateral line. This is the reverse of the usual geographic cline for such meristic characters in freshwater fishes. However, the sample of Georgia specimens is inadequate for comparison with the larger sample from Alabama. The question presented is, would an adequate sample from Georgia strengthen the possibility of the presence of two subspecies or would it show the populations to be similar?

During the study of *Hadropterus nigrofasciatus* previously mentioned (Crawford, *op. cit.*: 1-145), several samples of *Hadropterus palmaris* were collected and studied from Georgia (13 specimens) and Alabama (3 specimens). Additional specimens from

Georgia (20) were studied at the United States National Museum and one series of four specimens from Alabama was obtained from Alabama Polytechnic Institute. All additional samples again represent the extremes of the range and serve to make a numerical comparison between the two populations more meaningful.

The following numbers and localities are new records of *Hadropterus palmaris*. Cornell University Nos.: 11843, Bartow Co., Ga., Stamp Cr.,  $\frac{1}{4}$  mi. above jct. McKaskey Cr.; 17328, Pickens Co., Ga., trib. Talking Rock Cr., 9.4 mi. E. of Fairmount on Rte. 53; 21330, Dawson Co., Ga., Amicalola Cr., 3.4 mi. W. jct. Rte. 183 on Rte. 53; 21336, Pickens Co., Ga., trib. Etowah R., 5.3 mi. W. Pickens Co. line on Rte. 53; 21158, Cherokee-Calhoun Co. line on Rte. 74, Ga. Alabama Polytechnic Institute No. 580, Lee Co., Ala., Saughatchee Cr., Waverly-Opelika Hwy. United States National Museum No. 162377, Floyd Co., Ga., 12 mi. SW. Rome on U. S. Rte. 411.

If we now incorporate the data of the author and again draw a line between 63 and 64 lateral-line scales, an average divergence of only 63.1% is attained. For the pectoral rays the best line of separation may be drawn between 13 and 14 rays, which gives an average divergence of only 55.0%. Both characters show an average divergence of far less than the 80% required for subspecific separation as defined by Ginsburg. Furthermore, no indication of a cline is suggested.

It appears that *Hadropterus palmaris* is a stable species throughout its range. If intraspecific variations were present, it would most likely have been noted when specimens from the extremes of the range were compared.

I wish to extend thanks to Reeve M. Bailey and C. Richard Robins for suggestions concerning the manuscript.—RONALD W. CRAWFORD, *Department of Zoology, San Diego State College, San Diego 15, California.*

THE FOOD AND GROWTH OF THE WHITE CRAPPIE, *POMOXIS ANNULARIS*, IN PYMATUNING LAKE, PENNSYLVANIA AND OHIO.—The growth of fishes varies markedly in different regions because of different climatic and other environmental conditions. Because of its separation into three more-or-less distinct parts, Pymatuning Lake offers a unique opportunity to study the effect on fish growth of different ecological conditions in adjoining bodies of water with the same water supply. The aims of the investigation were to compare the growth of Pymatuning Lake white crappies with that of the species in other waters, and to compare the food and growth of the white crappie in the three parts of Pymatuning Lake.

Nearly all the specimens were collected in large

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trap nets operated by the Fish Control Unit of the Pennsylvania Fish Commission, but seines of various sizes and hook and line were also used. Total length, defined as the greatest length from the anterior tip of the head with the mouth closed to the posterior tip of the caudal fin with the rays pressed together (Deason and Hile, 1947, Trans. Amer. Fish. Soc., 74 (1944): 88-142), was taken on all specimens. Weight was measured on a spring balance or on a triple-beam balance. Total length measurements were used in all calculations involving length because it is the easiest measurement to make with accuracy, it is the measurement most widely used and understood by fishery workers and anglers, and because it is the most reliable measure of length (Carlander and Smith, 1945, COPEIA (1): 7-12; Hile, 1948, Trans. Amer. Fish. Soc., 75 (1945): 157-64; Royce, 1942, *Ibid.* 71 (1941: 270-4). Volume of stomach contents was estimated by dropping the contents into water in a graduated cylinder. Food found in the esophagus was considered to be in the stomach, but intestinal contents were not included. The widely accepted scale method of age determination was used. No difficulty was encountered in reading the scales.

**PYMATUNING LAKE.**—Pymatuning Lake (Fig. 1) lies on the Ohio-Pennsylvania state line 55 miles east of Cleveland. Its major tributary is the Shenando River which, after leaving the lake, flows 40 miles south into the Beaver River, a tributary of the Ohio River. The upper of the lake's two dams impounds the waters of the Upper Reservoir or Sanctuary Lake, an important wildlife refuge in which no hunting or fishing is permitted. Sanctuary Lake forms the northeast three miles of Pymatuning Lake. It has sand and mud bottoms, swampy, sandy or brushy shores, many stump areas, and some 22 islands. Its average depth is six feet.

The Lower Reservoir is divided into two parts, commonly called Middle Lake and Lower Lake, by an earth and stone causeway bearing a road and having two water passageways, each 30 feet in width, joining Middle Lake with Lower Lake. Middle Lake is 9 miles long, has an average depth of 12 feet, and has three large islands and several small ones. Shores have many stumps and much brush. There are rocky beaches along the southeast shore and sandy beaches along the west shore. Angling is permitted in Middle Lake but the use of motors is forbidden.

Lower Lake, lying between the causeway and the lower dam, is 9 miles long and reaches a depth of 40 feet. It has few stump areas. Shores are open and sandy in the northeastern part and rocky in the southeastern part. The western shores are characterized by sandy and brushy beaches. Pymatuning Lake and the surrounding region are described in

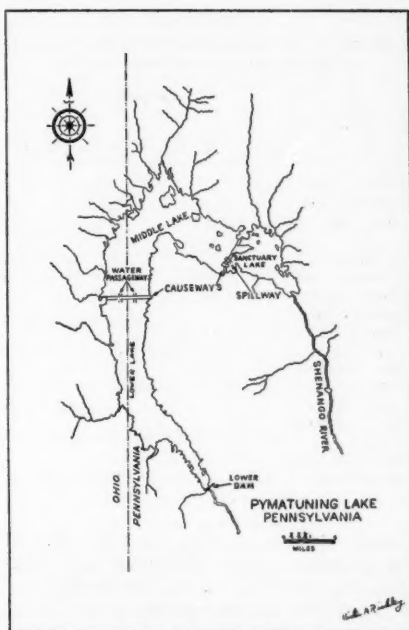


Fig. 1. Pymatuning Lake

greater detail by Tryon and Jackson (1952, Ecology, 33 (3): 342-50).

**Food.**—Limited observations were made on the food of white crappies. The stomach contents of 105 individuals were examined. Among smaller individuals the most common food item was Cladocera; Copepoda were next most common. *Notonecta*, *Chironomus* larvae and adults, and unidentifiable insect fragments were also found in stomachs of small individuals. In several collections, large percentages of the alga *Diplocystis* were noted. The only difference that could be noticed in the food habits of young from the different divisions of Pymatuning Lake was that Sanctuary Lake individuals had eaten a greater proportion of Cladocera than of Copepoda, while Copepoda were predominant in the stomachs of Middle Lake individuals. Tryon and Jackson (1952) reported that Sanctuary Lake had the most plankton (both plant and animal), Lower Lake had the least, and Middle Lake had an intermediate amount. Since the stomachs of 19.0 percent of the individuals from Sanctuary Lake were empty, 24.0 percent of those from Middle Lake were empty, and 17.6 percent of those from Lower Lake were empty, other factors than mere availability of food were apparently in operation.

Larger individuals were found to have eaten fishes almost exclusively, including carp, perch,

TABLE I  
AVERAGE TOTAL LENGTH IN MILLIMETERS OF WHITE CRAPPIES  
IN PYMATUNING LAKE AND OTHER WATERS

Water and reference	Age group							
	0	I	II	III	IV	V	VI	VII
Sandusky Bay, Ohio. Ohio Conserv. Bull. (1939).....	147	173	...	272	343	...	...	...
Lincoln Lakes, Ill. Thompson and Bennett (1939)...	117	132	150	155	168	...	...	...
Reelfoot Lake, Tenn. Schoffman (1940).....	...	...	239	257	287	315	348	361
Ohio. Langlois (1945).....	79	152	185	226	272	297	...	...
Lake Decatur, Ill. Hansen (1950).....	107	183	234	259	284	307	310	...
Pymatuning Lake. Present study..	55	121	157	199	234	251	268	284

bluegill, other white crappies, and gizzard shad. A few invertebrates, chiefly *Chironomus* larvae and adults, were found. In 13 adults from Middle Lake, *Diplocystis* composed 66.9 percent of the volume of stomach contents.

COMPARISON WITH GROWTH IN OTHER WATERS.—Total-length measurements of 472 white crappies from all three divisions of Pymatuning Lake were combined for comparison with growth in the following waters: Sandusky Bay, Ohio (1939, Ohio Conserv. Bull., 3 (4): 4-5); Reelfoot Lake, Tennessee (Schoffman, 1940, Rept. Reelfoot Biol. Sta., 4: 22-42; Ohio waters in general (Langlois, 1945, Ohio Div. Conserv. Nat. Resources, 40 pp.); and Lake Decatur, Illinois (Hansen, 1950, Bull. Illinois Nat. Hist. Surv., 25 (4): 211-65). Table I presents data concerning the growth of white crappies in these waters and in Pymatuning Lake. An extensive summary of white crappie growth in various waters has

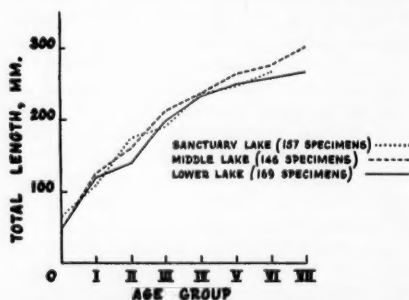


Fig. 2. Growth of white crappies in the three divisions of Pymatuning Lake.

been published by Carlander (1950, Coop. Fish. Res. Inst., pp. 197-201).

Most rapid growth of white crappies in the waters compared was that in Sandusky Bay, and only Reelfoot Lake produced specimens as long as did Sandusky Bay. Thompson and Bennett (1939, Illinois Nat. Hist. Surv. Biol. Notes No. 11: 1-24)

TABLE II  
LENGTH AND WEIGHT OF WHITE CRAPPIES IN PYMATUNING LAKE, 1948 TO 1951

Age group	Number of specimens	Average total length, mm.	Average standard length, mm.	Average weight, gm.	Standard deviation of total length
Sanctuary Lake					
0	8	65	47	3	14.36
I	0	...	...	...	...
II	1	173	130	28	...
III	13	190	138	95	41.25
IV	35	236	186	182	20.62
V	64	244	198	224	17.31
VI	36	269	214	288	25.51
Middle Lake					
0	20	51	42	2	7.38
I	24	124	97	28	17.41
II	20	160	120	39	19.50
III	16	211	171	123	26.06
IV	22	236	187	168	11.31
V	16	262	189	241	18.98
VI	18	277	236	333	31.87
VII	10	302	...	398	21.96
Lower Lake					
0	20	51	32	1	18.76
I	14	119	...	28	15.88
II	26	140	...	33	6.93
III	19	196	175	87	33.99
IV	25	231	191	54	10.40
V	36	249	192	190	23.46
VI	20	259	201	204	18.22
VII	9	267	229	242	35.41

TABLE III  
ANALYSIS OF COVARIANCE OF WHITE CRAPPIE WEIGHTS IN THE THREE DIVISIONS OF PYMATUNING LAKE  
 $x$  = length  $y$  = weight

Source of variation	D.F.	Sums of squares and products			Errors of estimate		
		Sx <sup>2</sup>	Sxy	Sy <sup>2</sup>	Sums of squares	D.F.	Mean square
Total.....	149	1311.30	3044.28	8420.54	1351.41	148	...
Lake.....	2	9.06	45.26	267.88	...	...	...
Within lakes....	147	1302.24	2999.02	8152.66	1244.74	146	8.52
For test of significance of adjusted means..					106.67	2	53.33

$$F = 6.25^{**}$$

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From pies in length of ences ran Unpublis 29 pp.) had the following cal Meth to comp divisions adjusted subsam. fish in Ch basis of (Table I 6.25\*\*, in level of F (Sn

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reported that white crappies from Lincoln Lakes were numerous and stunted. Lincoln Lakes was the only one of the compared waters that showed poorer growth for the species than did Pymatuning Lake, which supports the opinion of local fishery workers and anglers that Pymatuning Lake is becoming a "white crappie lake."

**GROWTH IN THE THREE DIVISIONS OF PYMATUNING LAKE.**—One hundred and fifty-seven specimens were collected in Sanctuary Lake, 146 in Middle Lake, and 169 in Lower Lake. The growth in these three divisions is compared graphically in Figure 2, which is based upon the data in Table II.

From age group II to age group VII white crappies in Middle Lake exceeded the average total length of fish from the other two divisions by differences ranging from 8 mm. to 35 mm. Cargo (1950, Unpublished Master's Thesis, Univ. Pittsburgh, 29 pp.) reported that Middle Lake white crappies had the best condition factor. Covariance analysis, following the procedure of Snedecor (1950, Statistical Methods, 4th Ed.), was used in the present study to compare weights of specimens from the three divisions of the lake. These calculations used the adjusted means of total lengths and weights of three subsamples of 50 individuals each. Thus weights of fish in the samples were tested for differences on the basis of common length. The test of significance (Table III) gave the variance ratio,  $F$ , equal to 6.25\*\*, indicating high significance at the 1 percent level of confidence in Fisher's table of distribution of  $F$  (Snedecor, 1950).

The physical and biological characteristics of Pymatuning Lake are as yet not thoroughly known, although ecological investigations are in progress at the Pymatuning Laboratory of Field Biology. The most obvious difference among the three divisions

of the lake is in depth, with Sanctuary Lake shallowest, Lower Lake deepest, and Middle Lake intermediate. A further difference is that angling is forbidden in Sanctuary Lake, which consequently has no fishing pressure (except that resulting from the removal of a small number of crappies incidental to other operations of the State Fish Hatchery at Linesville, Pennsylvania). In Middle Lake motorboats are forbidden; this results in lighter fishing pressure than in Lower Lake, where motorboats are used and anglers are more plentiful.

If the differences in fishing pressure were responsible for the difference in growth rates, then according to present beliefs (Langlois, 1939, Ohio Conserv. Bull., 3 (1): 16-7) growth should be best in Lower Lake and poorest in Sanctuary Lake. Since this was not the case it is assumed that differences in fishing pressure were not great enough to be effective. With the information at present available it is only possible to suggest that the moderate depths of Middle Lake, together with the extensive stump areas and optimum fishing pressure, provided the most favorable conditions for white crappies. That young-of-the-year had the longest average total length in Sanctuary Lake suggests that the abundant plankton population and relatively large amount of shallows had a favorable influence on the growth of young white crappies.

**Acknowledgements.**—Grateful acknowledgement is made of the assistance of Dr. C. A. Tryon, Jr., and Messrs. Gordon Trembly, Howard Fox, Frederick Riedel, Carlyle Sheldon, William Neely, David Cargo, Arthur Werner, Frank Schwartz, Milan Drake, and Frank Sieminski. This paper is Contribution No. 7 of the Pymatuning Laboratory of Field Biology, University of Pittsburgh.—DONALD E. MARCY, *Youngstown College, Youngstown, Ohio.*

## REVIEWS AND COMMENTS

**OBSERVATIONS ON THE LIFE HISTORY AND SENSORY BEHAVIOR OF THE SNAKE MITE, *OPHIONYSSUS NATRICIS* (GERVAIS) (ACARINA: MACRONYSSIDAE).** By Joseph H. Camin. Chicago Academy of Sciences, Special Publication No. 10, 1953: pp. 1-75, pls. 1-3, text-figs. 1-32. \$1.50.—The infestation of snakes by mites is so familiar a phenomenon to herpetologists, who have either had experience with it themselves (most of us having passed through a stage when we kept snakes in boxes) or are exposed to questions

from the snake-in-box-keeping public, that they will certainly wish to have the reference above. Dr. Camin's paper is a most competent and quite comprehensive study of the snake mite. The species proves to have an essentially world-wide distribution in zoological gardens, but is so rare on wild-caught snakes that its host in nature is not certainly known. Camin argues cogently that the original host is likely to be one of the large boas or pythons.

This paper is not directed toward the problem

of freeing collections of living snakes, or individuals, from the parasite. But the knowledge of the breeding habits and development of the mite here assembled is obviously essential to the working out of suitable prevention of, and prophylaxis against, mite infestation.—KARL P. SCHMIDT, *Chicago Natural History Museum, Chicago 5, Illinois.*

**SOUNDS OF THE AMERICAN SOUTHWEST.** Recorded by Charles M. Bogert. Folkways Records and Service Corp., New York: 12-inch, 33 $\frac{1}{3}$  RPM. \$6.45.—This series of recordings is an able attempt to document the summer sounds a person might be expected to hear in the arid Southwest. Most of the recordings are of sounds of animals in nature but a few of them are of captives. Most of the sounds were recorded in the Chiricahua Mountain and Tucson regions of Arizona but a few were "taped" in southern California. A Magnemite Tape Recorder was used.

First we hear sounds of the dry season in the Chiricahua Mountain area. The calls of the western mourning dove and the song of the mockingbird form a fitting introduction to those that follow: the squeal of the young javalina; the call of Stephen's whippoorwill; the hooting of the horned owl; the rattling of the western diamondback; the thrumming whir of the broad-tailed hummingbird; the drumming of the California woodpecker; the chirping of crickets; and a morning bird cacophony. Very appropriately the sounds of the wet season begin with a mountain thunderstorm followed by a flash flood of awesome proportions. The listener then hears individual calls, and/or mating choruses composed of one or more species of the following frogs and toads: western and Sonoran spadefoots, canyon treefrogs, and Great Plains, little green and desert toads. The squeaking of the long-horned beetle, the growl of the desert bobcat and other sounds are interspersed. The sounds on Side 2 of the disc, recorded chiefly in the Tucson and southern California regions, largely follow the pattern outlined here for the Chiricahua area.

In general the recordings are excellent and will be the source of pronounced nostalgia and good entertainment for many listeners and instruction for most. There are some unexplained background sounds that are intriguing and obviously natural. Since the recordings are without vocal commentary, the listener unacquainted with the sounds of western animals will find it difficult occasionally to decide just where one sequence stops and another begins. Usually, however, he will be able to follow rather easily by paying close attention to the written commentary furnished with the record.

The scientific value of these recordings is obvious for both behavioral and taxonomic studies. The

worth of the Cornell University efforts as well as that of others, projected and in progress in several parts of the country, will be greatly enhanced. It is to be hoped that not far in the future the combined efforts of the several investigators will be worked into a unified scheme.

An excellent essay along with views of mountains and deserts and pictures of the performers used in the recordings is included with the record. Enclosure of one of the specific names in quotation marks reveals that the recorder is still a systematist at heart.—NORMAN HARTWEG, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

**RESOURCE CONSERVATION: ECONOMICS AND POLICIES.** By S. V. Ciriacy-Wantrup. Univ. Calif. Press, Berkeley, 1952: 395 pp. \$6.50.—This book is aptly named, with perhaps more emphasis on economics than policies. The author has distributed the 21 chapters among five sections: (1) orientation, (2) private economics of conservation—optimum state, (3) private economics of conservation—economic forces, (4) social economics of conservation—objectives and criteria of conservation policy, and (5) social economics of conservation—implementation of conservation policy. An appendix contains a "Mathematical note on the theory of conservation." The chapters treat such varied subjects as the "Meaning of conservation," "Prices and price supports," "Taxation" and "International tools of conservation policy."

Resources are classified according to whether they are nonrenewable (stock) resources or renewable (flow) resources. Conservation is concerned with the "when" of use; it is defined as "changes in the time distribution of use rates of individual resources in which the aggregate weighted changes in use rates is greater than zero." Similarly, depletion (that protean word in fishery works) occurs when the "aggregate weighted change is less than zero."

This book will be of more general interest to economists than to readers of *COPEIA*, but all who are concerned with natural resources should read it. The last three chapters, dealing with domestic and international tools of conservation policy (including international wildlife conventions and treaties) and the coordination of conservation policy (including federal-state coordination), are especially pertinent.

Dr. Ciriacy-Wantrup makes it abundantly clear that conservation is primarily a socio-economic problem. While, in the case of wildlife conservation, biological information will enter into the resolution of the problem, the criteria for action (if a free choice is possible) will come largely from other fields. His objective study of resource conservation is a pleasant and constructive change from the

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endocrine reasoning which has characterized some previous treatments of the same subject.—JOHN C. MARR, *U. S. Fish and Wildlife Service, 450-B Jordan Hall, Stanford University, California.*

**GLI ANIMALI COMMESTIBILI DEI MARI D'ITALIA.** By Arturo Palombi and Mario Santarelli. Ulrico Hoepli Editore, Milano, 1953: 349 pp., 261 illus., 2 col. pls. Lira 3,800.—The authors have compiled a list of the edible fishes, tunicates, echinoderms, mollusks, and crustaceans of the Italian seas, considered by family groupings. The scientific names and the Italian vernaculars and various dialectal names are given for all genera and species considered. Also given are the established names for the animals used in the neighboring countries of England, Germany, Sweden, France, Switzerland, Holland, Portugal, Spain, Algeria, Tunisia, Malta, Arabia, Turkey, Greece, Yugoslavia, and Dalmacea.

Wherever possible each genus and species is illustrated by a drawing or photograph, and a descriptive text sufficient for identification is given. On the basis of acceptance by the population as food, the economic value is given for each genus and species. There is a short description of habit, seasonal abundance and methods used for capture. The book closes with a cross index and dictionary of 12,000 names of the organisms considered.

The authors in their preface state that the book is primarily intended for use by merchants, fishermen, and others who because of their occupation have need of knowledge of the edible animals from the sea. The scientific handling of the material, the clarity of description, and the dictionary of names in both Italian and other languages make this book a valuable addition to the scientific library of every worker interested in marine biology of the Mediterranean area. To those who contemplate work in the Mediterranean and the Adriatic, it is a "must". Those who have experienced working in this region, where in many cases traveling fifty miles or even less brings a complete new set of names for common organisms, will especially appreciate the value of this book. This reviewer spent the past year working in the Mediterranean area and had occasion to use this excellent manual to good advantage.—DOMINIC L. DEGIUSTI, *Department of Biology, Wayne University, Detroit 1, Michigan.*

**THE WESTERN END OF LAKE ERIE AND ITS ECOLOGY.** By Thomas H. Langlois. J. W. Edwards, Publisher, Inc., Ann Arbor, Michigan, 1954: xx + 479, 72 figs., \$10.00.—This book, written by an author who has lived for nearly 20 years surrounded by his subject, contains a wealth of information concerning the western end of Lake

Erie, with special emphasis on Ohio waters. The purpose of the book is clearly stated in the preface: "This report, summarizing a series of studies which have been made during a span of sixty years, aims to supply the basis for a fish management program for Ohio's part of Lake Erie." The author sets about this task by presenting a history of the biological work on the lake. Following this is a chapter entitled "The physical environment and some of its relationships with organisms," in which are discussed the geological history of the region, the action of wind and wave, shore line erosion and such other characters of the water mass as flow and pollution.

The above discussions set the scene for the discussion of the biota of the region, which includes groups of organisms from bacteria to mammals. The groups actually considered are: bacteria, algae, leafy aquatic plants, protozoans, sponges, coelenterates, helminths, rotifers, annelids, arthropods (including some crustaceans and insects), bryozoans, molluscs, and of the chordates, the mammals, birds, reptiles, amphibians and fishes. The fishes, which naturally receive more attention than the other groups, are discussed under four separate headings: fishes and their relationships with the environment—in which are considered the various senses, growth and metabolism; fish collection records—which is an annotated list; fish breeding habits; and fish feeding habits. Of these four sections the one dealing with fish breeding habits is suggested to be the most valuable. Unfortunately the annotated list is arranged alphabetically by the scientific names of the species, which means that closely related species are widely scattered throughout the list.

Next follows a chapter on the fisheries and a discussion of the various methods of capture such as by gill-net, trap-net or angling, and in which the discussions are primarily confined to the situation prevailing in Ohio. Here also is a further discussion of the decline of the cisco fishery which the author considers may have been due to "unfavorable environmental conditions" rather than overfishing.

In the summing up, the discussion of the sources and possible effects of the turbidity of Lake Erie waters will be of considerable interest to anyone who has been concerned with the fisheries of the Great Lakes.

The chapter dealing with fish management and fish management methods is well written and should be read by all who are sincerely interested in having a better understanding of the aquatic environment and the problems it presents.

Parts of the book, such as those concerning the proposed international agreement, have a strong political, rather than biological, flavour. Some statements, too, are extravagant; thus, the claim that "the Americans take 70% of the total amount of fish removed from Lake Erie" may have been true

in the 1930's but recent figures (1944 to 1952) indicate an average of 60% rather than 70%.

There are some parts of the book which, if revised, would greatly assist the reader; for example, the discussion of fishes under the three headings of occurrence, breeding and food habits is confusing and forces the reader to consult the index.

Certain species are not considered in the annotated list, although these are known to occur in Canadian waters of the lake and its tributaries. Specifically, these species are brown trout, rainbow trout, lake trout, American eel and American brook lamprey. Also, the south shore of Lake Erie is said to represent "about the northern limits of distribution" for *Dorosoma cepedianum*, but this is a common species on the north shore of the lake.—W. B. SCOTT, *Royal Ontario Museum of Zoology and Palaeontology, 100 Queen's Park, Toronto 5, Canada.*

**HYDROGRAPHY IN RELATION TO FISH-ERIES.** By John B. Tait. Edward Arnold and Co., London, St. Martin's Press Inc., New York, 1952: xii + 106, frontis., 19 text-figs. \$2.00.—This is the ninth in the Buckland Lectures series. Given in 1938, these lectures relating hydrography to fisheries were delayed in publication by the war, but the text was brought up to date before going to press.

The author offers no apology for confining his discussion almost entirely to the North Sea, and to the studies of British and Norwegian workers. Indeed, no apology is needed, for following the Challenger Expedition (1872-76), and the inauguration (1901) of the International Council for the Exploration of the Sea, hydrographic studies have formed an integral part of biological fisheries investigations in this important fishing region, and the relationship between hydrography and the fisheries is perhaps better understood here than anywhere in the world.

The following physical factors are considered: temperature, depth, pressure, salinity, osmotic pressure, light intensity, viscosity, and currents. The effects of each are discussed in relation to the various life-history stages, from developing egg to adult, and it is conceded that temperature and ocean currents exert the most pronounced effects on fishes.

Chemical factors discussed are pH, oxygen, various inorganic materials, such as Na, Mg, Ca, Cu, Fe, N, P, and Si, and organic substances, such as the growth-promoting factors in sea water. The phenomenon of upwelling, though physical in origin, is treated in this chapter as an agent in the renewal of nutrients to the euphotic zone.

The author obviously believes that variations in fish abundance are caused primarily by natural forces, and he shows rather convincingly how changes in the amounts of Atlantic water entering

the North Sea influence the concentrations of phosphate and nitrate, how these changes in the nutrient supply are followed by variations in the phytoplankton crop, and how these in turn lead to fluctuations in abundance of larval fishes, and finally to changing fortunes in the fisheries.

As a reference work, the book has limited value, for it lacks a bibliography. With few exceptions the literature citations are quite inadequate as reference material. Only one American paper is cited, and it is regrettable that the important pioneering work of Riley on marine productivity, Collier on the effects of dissolved organic substances on animal activity, and various U. S. Fish and Wildlife Service scientists on the location of new oceanic fishing grounds in mid-Pacific through hydrographic studies, were not at least mentioned as promising new approaches. The rapid strides in instrumentation made by American workers in recent years, by which such ingenious devices as von Arx's geomagnetic electric kinetograph were developed, also merit recognition.

On the other hand, the author has developed his argument along positive lines, and has avoided the pitfalls involved in the mere search for statistical correlations between physical or chemical, and biological variables. The book should be read by every marine scientist and others interested in the economy of the sea. Many will be stimulated to investigate the subject further.—J. L. McHUGH, *Virginia Fisheries Laboratory, Gloucester Point, Virginia.*

**THE FRESHWATER FISHES. VOLUME I. KEY TO GAME AND COMMERCIAL FISHES OF THE PROVINCE OF QUEBEC.** By Vianney Legendre. Game and Fisheries Dept., Prov. of Quebec, Montreal, 1954: 180 pp., many text illus., 3 maps, figs. 1-80. \$2.00.—This is a modified version of the first edition, in French, which appeared in loose-leaf form and smaller format in December, 1952. The revision is issued simultaneously in English and French, the second French edition being published (March 1) one day before the first English edition. The initial French edition is important to systematists chiefly in that it contains the original description of *Moxostoma hubbsi*, a replacement name for *Megapharynx valenciennesi* Legendre, 1942.

The freshwater fish fauna of Quebec comprises 101 species in 63 genera and 24 families. Included are exotic species (such as *Esox masquinongy ohienis*), anadromous forms (*Morone saxatilis*), euryhaline types (*Gasterosteus aculeatus*), and those occasionally encountered in fresh water (*Fundulus heteroclitus*). Following a formal listing of the species, with English and French vernaculars, there is a profusely and well-illustrated key that was obviously

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prepared with great care and thought. The 63 species (plus 5 additional subspecies) regarded to be of sport and commercial value are keyed out; the arrangement of the key is a modification of that adopted by Hubbs and Lagler, and is prefaced by instructions for its use. Each family or genus is illustrated by one or more line drawings in the body of the key, as are also certain diagnostic structural features necessary for proper identification. A glossary of technical terms, much of it illustrated, follows the key, and then comes a well-chosen bibliography (8 pages) and a very complete alphabetical index to common as well as scientific names. To facilitate ready use, long established but recently changed names are also indexed, e.g. *Boleosoma*, and the often numerous vernaculars for a single species are cross-indexed. Such deference to the user is characteristic of this work.

Following the index are 80 figures, of which the first 6 are outline drawings of various fish types (from sturgeon to perch), while the remainder are half-tone reproductions of the species and subspecies treated in the key. Most of these have been published before (as by Forbes and Richardson) but 5 photographs (*Calostomus c. calostomus*, *Moxostoma valenciennesi*, *M. hubbsi*, *Ameiurus n. nebulosus* and a young *Micropterus d. dolomieu*) represent originals.

There are some major changes in classification and nomenclature. The Coregonidae is united with the Salmonidae, and the Moronidae with the Seranidae. The following, regarded as valid genera until very recently, have been synonymized: *Entosphenus* with *Lampetra*; *Pomolobus* with *Alosa*; *Leucichthys* and *Prosopium* with *Coregonus*; *Cristivomer* with *Salvelinus* (see also last issue of COPEIA); *Amphiodon* with *Hiodon*; *Placopharynx* and *Megapharynx* with *Moxostoma*; *Roccus* and *Lepibema* with *Morone*; and *Boleosoma*, *Catonotus* and *Poecilichthys* with *Etheostoma*. The following nominal forms have been modified: *Salvelinus marstoni* (made a subspecies of *alpinus*); *Esox vermiculatus* (a subspecies of *americanus*); *Moxostoma rubreque* (synonymized with *M. valenciennesi*); *Schilbeodes gyrinus* (= *S. mollis*). Only one species, *Moxostoma hubbsi*, is listed as confined to Quebec.

It is unfortunate that specific reasons for some of the above changes have not been presented either in this contribution or in other papers by earlier advocates of the consolidation of family and generic groups. Failure to explain such changes often leaves the general worker in a quandary, and, while I agree that many of the proposals are justified and reasonable, change in itself does not contribute to the understanding of classification.

The maps, in four colors, are intended to show provisional distributions. For example, on the dis-

tribution map for the walleye, sauger, perches and striped bass, the gap in the range of the perch, between Ottawa River and James Bay, has been partly bridged since the map was drafted. Mr. Legendre thus advises me that the maps constitute a progress report, summarizing knowledge obtained from an incomplete review of the literature and from field work.

The booklet is reproduced by offset photolithography of electric typewriting (justified margins) on a 9 × 6 inch overall format, with a pleasing cover design. The author, the Quebec Department of Fish and Game, and others associated with the preparation of this attractive publication are to be congratulated.—ROBERT RUSH MILLER, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan*.

**CHECK LIST OF PHILIPPINE FISHES.** By Albert W. Herre. Fish and Wildlife Serv., U. S. Dept. Interior, Washington 25, D. C., 1953; Research Rept. 20: 977 pp. \$2.25 (paper covers).—One great difficulty encountered by the biologists of the Fish and Wildlife Service's Philippine Fishery Program (1947–1950) was that, although there were some fine systematic works dealing with certain limited groups of fishes, the overall systematic picture was very inadequate. The need for a thorough check list based on the study of new material, as well as a critical analysis of existing records, was quickly evident in every fishery studied.

Dr. Herre's check list is in response to this need. It is a careful and well-documented work which required more than three years to complete. The list of 2,179 species approaches Dr. Herre's estimate of a total fauna of approximately 2,400 species. Many errors in early locality records have been clarified, and in most cases subspecies have not been listed. Although the synonymies are not complete, they are given in sufficient detail that no difficulty will be experienced. The check list is of particular value because it brings together a list of Dr. Herre's extensive collections which, taken together, are undoubtedly the largest and most important ever made in the islands. His first Philippine catches were made in 1920, and in the 33 years since that time he has been actively engaged in ichthyological and fisheries studies dealing with this region.

The new check list is unquestionably one of the most important contributions of the Philippine Fishery Program, especially in terms of future benefit to the fisheries and ichthyology of the islands. The Fish and Wildlife Service is to be commended for sponsoring and making available this fundamental work.—EARL S. HERALD, *Steinhart Aquarium, California Academy of Sciences, San Francisco 18, California*.

**RECENT LITERATURE ON FAR NORTH-ERN FISHES.**—The past decade has witnessed a renewed interest in the arctic and subarctic areas of the world. In North America, investigations sponsored by the Canadian and United States governments have included a significant amount of ichthyological and fishery research, the results of which for the most part are as yet unpublished. Field studies in the arctic present some unique problems, but the student of the far northern biota is faced with greater difficulties than drifting ice and frozen nets upon his return to the laboratory. Perhaps in no other area of the world is the biological literature to be found so scattered among non-technical journals and travel narratives. The ichthyologist finds that many references are missed in Dean's *Bibliography of Fishes*. Apparently the situation was similar in other disciplines.

The delay and difficulties brought about by the urgent need for a key to arctic literature resulted in the government sponsorship of a bibliographic project to encompass all fields of endeavor concerned with the far North.

This extensive task has culminated with the publication of: **ARCTIC BIBLIOGRAPHY**. Prepared for and in cooperation with the Department of Defense under the direction of the Arctic Institute of North America. Three volumes, 4,478 pp., U. S. Government Printing Office, Washington, D. C. \$12.75 (sold in sets only).—These three volumes are the result of a project of the Arctic Institute of North America which began under Office of Naval Research sponsorship in 1947. Volumes 1 and 2 consist of over 20,000 separate title entries; Volume 3 contains a very complete cross index to those entries, forming one of the most useful keys to any subject or area yet published. A fourth supplementary volume is in press and material is being gathered for a fifth. I shall not join the ranks of bibliographic critics by listing omissions. Items have of course been overlooked, but the fact that additional references are being actively collected should provide the incentive to send such omissions to the editors of this work. My own bibliography on arctic ichthyology, based on some five years research, contains few references not listed by the *Arctic Bibliography*. Of particular value to the ichthyologist is the recording of a number of Russian publications which have been missed by the compilers of the *Zoological Record*. Translation to English of all foreign language titles and a brief summary of the contents of the papers concerned greatly enhance the value of this bibliography.

Another important item which may escape the attention of ichthyologists in the United States is: **THE FISHES COLLECTED BY THE CANADIAN ARCTIC EXPEDITION, 1913-18, WITH ADDITIONAL NOTES ON THE ICHTHYOFAUNA OF WESTERN ARCTIC**

**CANADA.** By Vladimir Walters. Ann. Rept. Nat. Mus. Canada, 1951-1952, Bull. No. 128, pp. 257-274.—The ichthyological collections of the Canadian Arctic Expedition seem to have been plagued with misfortune. A considerable portion of the material collected along the northern coast of Alaska was lost (as was the collector) with the ill-fated KARLUK. Mr. Frits Johansen, one of the expedition's naturalists, prepared the original report on the fishes for inclusion in the extensive series of published works treating the results of the Expedition, but unfortunately his manuscript was never published. It remains extant at the Canadian National Museum, Ottawa. A number of workers have since examined individual specimens from the collection and a second complete study of the material was carried out by Henry H. Hildebrand, but this was never published. Mr. Hildebrand included notes on this collection in his thesis submitted to McGill University for the degree of Master of Sciences (1948). ("Marine Fish of Arctic Canada", 123 + xiv pp.) Not knowing of Mr. Hildebrand's efforts, Mr. Walters undertook a third study of the collection and has been fortunate in bringing to light, after almost forty years, the ichthyological results of the Canadian Arctic Expedition. The paper includes a number of interesting records for these waters. Unfortunately, Mr. Walters did not have the opportunity to examine page proof of his paper and a few errors have crept in to the published results. These will be easily detected by the student of northern fishes.

Mention also should be made of another contribution by the same investigator: **NOTES ON FISHES FROM PRINCE PATRICK AND ELLESMERE ISLANDS, CANADA.** Amer. Mus. Novitates, No. 1643, pp. 1-17, 1953.—This record of Mr. S. D. MacDonald's collections made during his stay at some of the far northern weather stations provides some interesting distributional and faunal data from little-known regions.

Speculation on the ability of the Alaskan blackfish to revive after being frozen has existed ever since L. M. Turner's (1886, Contrib. Nat. Hist. of Alaska, p. 101) original remarks concerning the regurgitation of "frozen" blackfish upon being thawed out by the body heat of the dogs to which they were fed. This question is dealt with in: **STUDIES ON THE PHYSIOLOGY OF FROZEN PLANTS AND ANIMALS IN THE ARCTIC.** By P. F. Scholander, Walter Flagg, R. J. Hock, and Laurence Irving. Jour. Cellular and Comp. Physiol., Suppl. 1, Vol. 42: 1-56, 1953.—Section VII of this report, entitled "Experiments on freezing of the blackfish (*Dallia pectoralis*)," deals the death blow to the quasi-scientific myth concerning the recovery of the Alaskan blackfish after freezing. It is concluded from experimental work conducted at the Arctic Re-

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search Laboratory, Point Barrow, Alaska, that total freezing, as well as many stages of partial freezing, invariably kills the fish. A number of interesting experiments are described which form the basis for the reported conclusion.—NORMAN J. WILLMOVSKY, *Natural History Museum, Stanford University, California*.

**TRAITÉ DE PISCICULTURE.** By Marcel Huet. Editions La Vie Rustique, 299 Avenue Georges Henri, Brussels, Belgium. Second Edition, 1953: xii + 371, with 280 illustrations, chiefly photographs. Heavy paper, 270 Belgian francs, cloth, 330 B.f.—Demand for this handbook of fish culture has led to publication of a second edition only a year after appearance of the first. Principal changes in the second edition include revision and expansion of the section on culture of species of the cichlid genus *Tilapia*, and inclusion of a form suggested for use in maintaining records of pond production and control.—JUSTIN W. LEONARD, *Michigan Department of Conservation, Lansing 26, Michigan*.

**MARINE TROPICALS.** By Ed L. Fisher. Sub-Marine Studios, 918 Langford Building, Miami 32, Florida. 1954: 55 pp., 4 pls., \$1.50.—The author evidently has had considerable experience in dealing with marine tropical fish, but unfortunately this is not conveyed adequately to the reader. Some errors could have been eliminated by careful proof reading. A co-author might have solved the problem of organization and presentation.—L. C. FINNERAN, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan*.

**KEEPING AND BREEDING AQUARIUM FISHES.** By C. W. Emmens. Academic Press Inc., Publishers, New York, 1953: x + 202 pp., illus. \$4.50.—This is a fine book, but, incredibly, it does not contain a bibliography. The detailed presentation given here shows a thorough knowledge of the literature. The author's extensive experience is reflected by his judgement and interpretation of data pertinent to aquarium keeping. Included is information on aquarium-fish anatomy, physiology, breeding, raising, diseases and medications. Both freshwater and marine environmental maintenance are discussed.

A categorical presentation of some data may offend a few. For example, it is said of the lateral line: "Its function is to detect vibrations of low frequency, and the *ear* [author's italics] is a specialized part of the lateral line system." Also, "The air bladder controls the specific gravity of the fish, as the driving tanks of a submarine govern its buoyancy."

Few salient errors have occurred. In the discussion of sexual behavior in livebearers, it is stated that "insemination is very rapid and frequent." The author also reports that coition is not internal "but that packets of sperm are shot from [the gonopodium] when it is in close proximity to the genital aperture of the female, and that some of them find the target." Obviously, the excellent paper on guppy behavior by Clark and Aronson has been overlooked.

The adequate illustrations support the text. This is a refreshing change from the pictures for pictures' sake, common in many publications.—L. C. FINNERAN.

**FOUNDATIONS OF ICHTHYOLOGY.** By E. K. Suvorov. 2nd ed., enlarged. "Sovetskaya Nauka" Press, Moscow, 1948. 579 pp., 402 figs.

**SPECIAL ICHTHYOLOGY.** By G. V. Nikolsky. "Sovetskaya Nauka" Press, Moscow, 1950. 436 pp., 301 figs.

**FISHES OF THE FRESH WATERS OF THE USSR AND NEIGHBOURING COUNTRIES.** By L. S. Berg. Academy of Sciences Press, Moscow, 1949. 4th ed., 3 volumes, 1381 pp., 946 figs., 1 map.

**THE GADOID FISHES.** By A. N. Svetovidov. [Fauna of the USSR, Fishes, Volume 9, No. 4.] Academy of Sciences Press, Moscow, 1948. 221 pp., 38 text figs., 72 plates.

**COMMERCIAL FISHES OF THE USSR.** Edited by L. S. Berg, A. S. Bogdanov, N. I. Kozhin and T. S. Rass for the Federal Research Institute for Marine Fisheries and Oceanography. *Pishchepromizdat* [Food Industries Press], Moscow, 1949. Vol. 1 (Text), 787 pp., 10 color plates and numerous text figures; Volume 2 (Atlas), 230 color plates (9½ × 13 inches).

The five works above, all printed since World War II, indicate a continued interest in ichthyology in the USSR. Suvorov's book is a general work in one volume, the Russian equivalent of Jordan's or Norman's treatise—from which, indeed, many of its illustrations are taken. After an introduction devoted to the history of ichthyology, the first division of the work deals with morphology and embryology. The second is a series of chapters of interest to the "fishery" biologist (age and rate of growth, means for differentiating races, effects of environment upon fish, fish and other organisms, food, reproduction, migration). The third concerns geographic distribution, phylogeny and palaeontology; and the fourth is a systematic account of representative living and fossil fishes.

Nikolsky's "Special" (Chastnaia) Ichthyology covers much the same ground as the last section of Suvorov's work. The additional space makes possible more detail concerning migrations, growth, etc., of individual fishes, their commercial production,

and so on. The illustrations too are clearer and chosen from a wider field; for example, there are some good drawings made from Forbes and Richardson's already widely-copied plates. There is also a "General Ichthyology" by the same author, which became available during the war.

Neither Suvorov's nor Nikolsky's book is likely to become required reading for western ichthyologists, but the next two are treatises which no major museum that includes fishes can afford to be without. Fortunately both are issued by the Academy of Sciences, which right through the post-war years has managed to keep its biological publications available to any persistent outsider. Many will already possess one of the earlier editions of Berg's *Freshwater Fishes*, but the present fourth edition will be the definitive version. Apart from its value in systematics, it contains a wealth of detail concerning each species, including their growth in different waters, commercial production, migrations, etc. As well as strictly freshwater fishes, the work includes anadromous and catadromous species, and various flounders, cods, pipefishes, etc., that are usually thought of as strictly marine.

Svetovidov's *Cods* has the appearance of being a careful and comprehensive work. It deals with Gadidae and minor related families, including keys to and descriptions of extralimital species as well as those which impinge upon the USSR. The text figures are mainly distribution maps. The plates illustrate the general appearance of the fish, also the skull, vertebral column and other bones, for most of the species.

The Atlas of the "Commercial Fishes of the USSR" is an ambitious work, with 230 species drawn in color by an artist who was not afraid of color, but who apparently did not always have fresh material to work from. The accompanying text has two or three pages for each species, including a brief characterization, distribution in USSR waters, biological information, commercial catch in various regions (usually for 1936-39) and methods of fishing. Much of this duplicates what is in Berg's *Freshwater Fishes*, but most of the marine species are additional. Either work is invaluable as a guide to other Russian literature, because for each fish the vernacular names in use in different parts of the USSR are given, as well as standard names in several foreign languages.—W. E. RICKER, *Pacific Biological Station, Nanaimo, B. C., Canada.*

**FUNDAMENTALS OF ECOLOGY.** By Eugene P. Odum. W. B. Saunders Company, Philadelphia, 1953: xii + 384, 119 figs., \$6.50.—In the preface, Professor Odum states that he has used four different approaches in teaching the subject matter of ecology: "(1) the 'factor' approach, in which the

important components of the environment, such as temperature, light, etc., are considered as they affect and control organisms; (2) the 'level' approach in which the individual, the population, and the community are successively considered; (3) the 'principles' approach, in which the broad principles and concepts are outlined; and (4) the 'environmental' approach, in which life is considered as it exists in the major environments, such as ocean, fresh water, and land." Professor Odum found the latter two approaches the most effective in teaching, and consequently the book was "organized with this experience as a guide." Thus, Part I of the book has eight chapters dealing with ecological principles, covering ecosystems and cycles, limiting factors, energy and food chains, population structure and dynamics, interspecific relations, and community relations. Part II, the habitat approach, discusses the ecology of organisms in fresh-water, marine, and terrestrial environments (three chapters). Part III is ecology applied to the conservation of natural resources including man.

Throughout, there is much emphasis on aquatic ecology, and on principles related to practical problems of conservation. Format, binding, printing, paper, and illustrations are excellent. A thirteen-page bibliography and an index with reference glossary are included.—GERALD P. COOPER, *Institute for Fisheries Research, University Museums Annex, Ann Arbor, Michigan.*

#### HANDBOOK OF FRESHWATER FISHERY BIOLOGY WITH THE FIRST SUPPLEMENT.

By Kenneth D. Carlander. Wm. C. Brown Company, Dubuque, Iowa, 1953: v + 429, 2 figs., 5 charts, lithoprinted. \$6.50.—The first edition of this book (reviewed in COPEIA, 1951 (1): 107) appeared in 1950. The "first supplement" was published in 1953 as a separate, pp. i-vi, 277-429, \$3.00; it contains summaries of data on age and growth of North American freshwater fishes, from the extensive literature during the years 1950-1953 plus many earlier references overlooked in the first edition, and data for many species not included in the first edition. The supplement also contains summaries of age and growth data given in the original Handbook. The original Handbook and the Supplement are available, bound in one volume, with a combined index for the two parts.

In addition to good coverage of literature on age, growth, condition factor and related aspects of fish biology, Professor Carlander is attempting to expand the Handbook by including abstracts and references to literature on fecundity, populations and yield, creel census statistics, mortality rates, returns from hatchery plantings, costs of hatchery production, and related subjects. Pre-

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sumably additional supplements will be forthcoming in the future, and authors of papers on the subjects cited above are encouraged to send reprints

to Professor Carlander at Department of Zoology and Entomology, Iowa State College, Ames, Iowa.  
—GERALD P. COOPER.

## EDITORIAL NOTES AND NEWS

J. E. Johnson, Jr.—An Appreciation

By Karl P. Schmidt

J. E. JOHNSON, JR., City Comptroller of Waco, Texas, and a well-known naturalist, was born September 27, 1895, in Waco, the son of the late Mr. and Mrs. J. E. JOHNSON. He attended Sacred Heart Academy and St. Basils, and after service in World War I, joined his father in the lumber business in Waco. In 1933 he was employed by the city as a collector of delinquent taxes, and became City Comptroller in 1942.

While in the Army, in 1918, he married MISS RUTH FULLER of San Antonio. He was a member of the James Edmond Legion Post, and had been its commander and finance officer.

Under the influence of JOHN K. STRECKER, the pioneer naturalist long at Baylor University, MR. JOHNSON became interested in collecting reptiles and amphibians, and this became an avocation to which he was devoted for 30 years. He became a member of the Southwestern Association of Naturalists, the Texas Herpetological Society, the Herpetologist's League, and the American Society of Ichthyologists and Herpetologists.

On March 21, 1954, while hunting snakes near Smith Bend on the Brazos, about 30 miles from Waco, MR. JOHNSON was struck by a rattlesnake some 4½ feet long, and received a full charge of venom in the back of his left hand. In spite of immediate first-aid and every medical treatment that could be given, he died in Providence Hospital, about 6 hours after being bitten.

To have known J. E. JOHNSON, JR., and above all to have gone snake-hunting with him, remain a privilege and a great good fortune for any herpetologist. As Comptroller of the city, with a history of distinguished public service, he was a well known figure in Waco. His avocation of snake hunting was well known to his fellow citizens, but few of them can have known that he had made the search and capture of venomous snakes a distinguished sport, and brought his practice of it to a professional level; still fewer knew how widely Ed was known and

respected among professional and amateur herpetologists the country over. ED JOHNSON was an amateur herpetologist, and thought of himself as such, and liked his amateur status. He never sold his snakes, but presented them to zoos and museums and individual students free of charge. As he continued collecting, he became in fact a professional so far as his skill and ability were concerned, and his knowledge of the habits and habitat and behavior of the snakes he hunted grew to the point at which his professional friends wished that he might commit some of it to paper.

The JOHNSON hunting ground at Waco lies astride one of the great faunal partitions in North America, with the East Texas lowland, to the east, continuous with the southeastern forest region of the continent, while the Edwards Plateau, to the west, above the spectacular feature of the Balcones Escarpment, is a characteristic part of the Great Plains grassland. I had met Ed in Waco in 1937, and after receiving snakes from him for the research collections of Chicago Natural History Museum for several years, it had become an obsession with me to get into the field with him. On my way back from an April reconnaissance in the Sierra del Carmen in 1945, I stopped off in Waco and was hospitably entertained by Mr. and Mrs. JOHNSON.

We then made two memorable collecting trips in the JOHNSON panel truck, accompanied by Ed's eager disciple JOHN SPARKS. We went first to the east, to a favorite collecting ground for the eastern copperhead in Limestone County, where I saw more copperheads than I had seen in all my previous 20 years of snake collecting. Then we went up to the plateau and canyon country to the west to collect prairie rattlers and diamond-backs, and with some luck got a fine broad-banded western copperhead. We collected a great variety of other snakes together with tarantulas and a wonderful green and yellow centipede, and came back rich in specimens and still richer in experience. It was good to see that Ed had another local naturalist friend in E. O. MILLER at China Spring, and the four of us made a snake-hunting team that might do credit even to the Texas Herpetological Society.

When we set out, I found that Ed had provided me with the conventional wooden snake stick, while he himself carried a steel crowbar made from the drive-shaft of an old Ford. It was soon evident that I was merely standing around while Ed and JOHN SPARKS were doing all the log-turning. Nothing less than a crowbar or canthook would move the kind of logs that had snakes under them. When I suggested that I could also use a crowbar, Ed admitted that he did have a light one for the use of visitors. This turned out to be the mate to his own, a half-inch shorter, and the offer of the light crowbar turned out to be one of Ed's standing jokes. When we moved to the Plateau, and had rocks to move instead of logs, two crowbars were even more effective. Ed was more careful in his handling of rattlesnakes than I, and took no needless chance of being bitten. That he lost his life from a rattlesnake bite was not an evidence of any growing carelessness on his part, but a testimony to the irreducible minimum of risk that remains in this operation, multiplied into 30 years. As Ed practiced snake hunting, it was a sport with more genuine thrill than any big game hunting with a rifle. Ed and I had planned a trip together into the Sierra del Carmen to look for the center of abundance of the endemic Big Bend snakes, like *Lampropeltis alterna* and *Elaphe subocularis*. It was a project we thought of as a kind of highlight in our lives. This project we must now turn over to our younger successors.

Sometimes a kind of tension operates as a barrier between a field naturalist and one with more book knowledge. No such barrier existed between Ed and myself; we had complete mutual respect, each for the other's abilities, and we survived the final test of compatibility in our camping trips together. I can only repeat that I learned a lot more during 15 days in the field with Ed than a lot of herpetologists will ever find out from reading books. J. E. JOHNSON, JR., of Waco, was in fact one of the most unforgettable characters I have known.—*Chicago Natural History Museum, Chicago 5, Illinois.*

#### News Notes

THE following article is gleaned from an article in the *Waco News Tribune*, March 22, 1954. MR. J. E. JOHNSON, JR., was struck on the back of his left hand by a [rattle] snake as it withdrew suddenly from the noose of a snake stick before it could be tightened. The snake was apparently unable to free its fangs, and the victim pulled it loose with his other hand. After killing the snake, one of MR. JOHNSON's companions immediately cut open the wound and applied a pump and a tourniquet. Due to distance and transportation

difficulties, approximately 2 hours and 15 minutes elapsed before a hospital was reached. There he was given devo plad, dextrose, acthar, anti-venom serum, antitetanus and penicillin; oxygen was administered continuously. MR. JOHNSON failed to respond and died about 4 hours after being admitted to the hospital.

M. GRAHAM NETTING has been named director of the Carnegie Museum. DR. NETTING, who has been acting director since last year, succeeds MR. WALLACE RICHARDS whose prolonged illness has prevented his continuing in the post.

MR. GEORGE MEADE has contributed his natural history library and a sum of money to the Department of Zoology, Tulane University. The library will be incorporated with that of the department to form a nucleus for the continued expansion of the research library in natural history. The microcarding of out-of-print herpetological materials is now in progress. A limited number of microcard copies of Boulenger's British Museum catalogs on amphibians and reptiles, 1882-1896 (9 vols.), are available. The group of 88 cards, each card containing an average of 60 pages, is available for \$16.50, plus a small servicing and packaging cost. Address orders to the Meade Natural History Library, Department of Zoology, Tulane University.

The following have received research grants from the American Association for the Advancement of Science: ALLEN D. LINDER, Oklahoma A. and M. College, for the propagation and habits of darters of the genus *Hadropetrus*. COLEMAN J. GOIN, University of Florida, for the preparation of a volume containing the original descriptions of all North American salamanders.

KENNETH S. NORRIS has been appointed Curator for Marineland of the Pacific, a recently completed oceanarium at Portuguese Bend, near Point Vicente Light, California. AL ALLANSON, also formerly employed at the Scripps Institution of Oceanography, has joined the staff as collector.

Attention is directed to the *Centro de Documentacion Cientifica y Tecnica*, created by the UNESCO Technical Assistance Mission in Mexico, and to its montly *Boletin*, now in its third volume. The Center has been organized to serve as a clearing house for scientific publications of interest to research workers in Latin America as well as the rest of the world. The Bulletin gives the titles, translated into Spanish and classified by subject, of all works published in some 2,000 world-wide scientific journals; these titles are also given in the original language. In addition, paper copies or microfilms of any of these works can be obtained from the Photographical Service of the Center. Subscription price is \$6.00 per year and the name and address

of the publisher are: Centro de Documentacion Cientifica y Tecnica, Plaza de la Ciudadela N° 6, México, D. F., México.

DR. PERIHAN SADOGLU of the University of Istanbul has been given leave to work at The American Museum of Natural History, in the laboratories of the Department of Fishes and Aquatic Biology. She arrived on March 8 and plans to spend a year engaged in a genetical analysis of the Mexican blind cave characins which have been under other study at the Museum laboratories for a number of years. DR. SADOGLU obtained her PhD last year on a study of ocular reduction in the cave flies of the Narlica Cave in Antakya under the sponsorship of DR. CURT KOSSWIG.

In recognition of GEORGE VANDERBILT's contributions to ichthyological research, the Board of Trustees of the Academy of Natural Sciences of Philadelphia has erected the GEORGE VANDERBILT CHAIR OF ICHTHYOLOGY. DR. ROBERT R. HARRY, Assistant Curator of Fishes, has been appointed to this Chair. DR. HARRY returned in February from six months of field work on Pacific atolls.

As in former years, his participation in these projects was sponsored by MR. VANDERBILT.

The Bulletin of Zoological Nomenclature, 1954, May 11, Vol. 9, Pt. 8, pp. 247-49, contains an article by HOBART M. SMITH entitled "Proposed use of the Plenary Powers to suppress 'Palmatotriton' Smith 1945 (Class Amphibia, Order Caudata)." SMITH, after giving reasons why he used a new name (*Palmatotriton*) for *Oedipus rufescens* Cope in a paper published in 1945 (Ward's Nat. Sci. Bull., 1 (1): 4), proposed that the generic name *Palmatotriton* Smith 1945 should be suppressed. The International Commission on Zoological Nomenclature would like to have the fullest possible presentation of views of interested specialists to aid it in making a decision. All correspondence regarding the above application must reach the Secretariat by November 11, 1954 and should be marked with the Commission's file number (File Z. N. (S) 594). Envelopes should be addressed as follows: MR. FRANCIS HEMMING, Secretary to the International Commission on Zoological Nomenclature, 20 Park Village East, Regent's Park, London, N. W. 1, England.

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